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IMPACT EVALUATION OF MORGANTOWN PRT 1975-1976 RIDERSHIP: INTERIM ANALYSIS

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FINAL REPORT

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16. Abstract

An analysis of the ridership levels of the Morgantown PRT system during its initial period of operation, the 1975-1976 academic year, is presented. PRT ridership by day, weekly ridership trends in terms of exogeneous events, the influence of feeder service on ridership, and the impact of system operating levels on ridership are involved. Data were obtained from West Virginia University management reports on daily ridership, and system operation and analyses included statistical tests of significance and multivariate statistical procedures.

The findings show that ridership by day of the week was proportionately similar throughout the 1975-1976 academic year, that a substantial amount of the interweekly ridership variance is due to the university schedule, and that weekend ridership, which is discretionary, was similar throughout the time period.

This report concludes that the PRT is a significant transportation mode for routine travel and that ridership is highly responsive to quantity of service offered.

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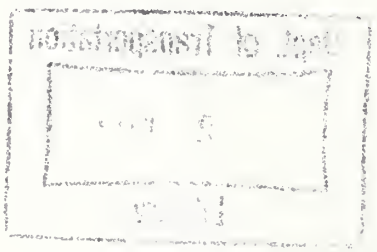


PREFACE

This report was prepared under PPA UM739, Morgantown PRT Impact Evaluation, sponsored by the Urban Mass Transportation Administration, Office of Technology Development and Deployment, AGT Applications Division, UTD-60, Steven Barsony, Director. It analyzes the ridership levels of the Morgantown PRT system during its initial period of operation between October 23, 1975, and April 28, 1976. During this period the PRT system was undergoing operational testing.

The Morgantown Personal Rapid Transit System is a new type of public transportation system which was built as a research development and demonstration project by the Urban Mass Transportation Administration. Consisting of three stations, 2.1 miles of two-lane guideway, and a 45-vehicle fleet, the system began passenger service in October 1975 (see the Bibliography for more information).

This Interim Analysis is a phase of the ongoing multi-year Morgantown PRT Impact Evaluation, designed to track ridership response to the evolving PRT system. The Pre-PRT Phase of the Impact Evaluation, conducted between January and June 1975, recorded travel patterns and ridership, by all modes, immediately prior to the initiation of PRT passenger service. The Post-PRT Phase of the Impact Evaluation, originally scheduled for a similar time during 1976, was postponed until January 1977, because of the PRT operational testing program during academic year 1975-1976. The need for this Interim Analysis arose because of the postponed Post-PRT Phase and because PRT passenger service was provided concurrent with the operational testing program during 1975-1976.

Many people contributed to different stages of this report. Steven Barsony, Philip Morgan, John Marino, UTD-60, David Rubin and Raymond Shih, TSC, provided conceptual and technical assistance in carrying out the study. Janet Burley, Raytheon Service Company, and Blanche Tripp, TSC, assisted in manuscript preparation.

EXECUTIVE SUMMARY

This Interim Analysis describes the PRT system ridership levels and trends during the 1975-1976 academic year. This analysis is a part of the ongoing, multiyear, Morgantown PRT Impact Evaluation. This Impact Evaluation has measured travel and traffic adjacent to the PRT during the spring of 1975 and is repeating these measurements during 1977, following introduction of PRT revenue service.

The Interim Analysis monitors initial PRT ridership during academic year 1975-1976 when the PRT system began passenger service while still undergoing operational testing. The analysis measures the influence of system operating characteristics and feeder service on PRT ridership. Data are drawn from West Virginia University management reports describing PRT system operating characteristics. Ridership volumes and trends show that:

a. Ridership by day of the week was very similar throughout the 1975-1976 academic year; typically, on Thursdays the PRT system carried the highest ridership.

b. A substantial portion of the interweekly ridership variations can be explained by changes in the university activities: e.g., examinations and vacations.

c. Weekend or discretionary use of the PRT system was relatively similar throughout the academic year.

Thus, the PRT system during 1975-1976 was a significant transport mode for routine intercampus trips.

Since the PRT system was still undergoing operational testing, its service was frequently quite unreliable. There were breaks in system operations and shortages of vehicles in operation. The analysis measured the impact on ridership of seven operating characteristics: fleet mileage, actual operating hours, system availability, trip reliability, vehicle availability, downtime frequency, and downtime duration. Of these, fleet mileage is most related to ridership. Thus, ridership was highly responsive to the

quantity of service offered.

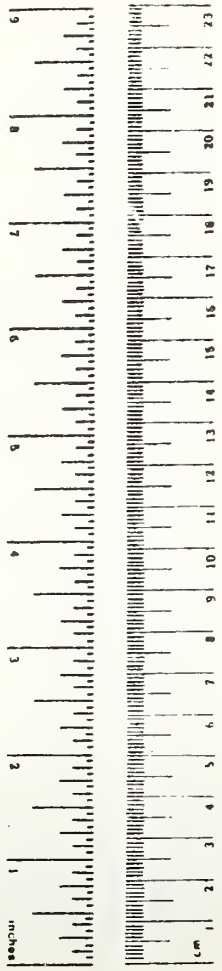
During January 1976, the service on the PRT system became quite unreliable, and repairs to the power rail had to be made, which required a three-week shutdown. The University, therefore, decided to offer, starting January 29, parallel bus service in competition with whatever PRT service might be available during the remainder of the school year. In spite of this competitive bus service, the PRT system retained 55 percent of its previous ridership. Ridership was very stable, particularly in late March and April when PRT service became more reliable and there were fewer variations in daily ridership due to university activities.

These ridership behavior patterns indicate that the PRT system was the preferred travel mode of many persons for routine intercampus trips. The currently ongoing Post-PRT Phase of the Morgantown PRT Impact Evaluation will report in detail the type of trips for which PRT is preferred, the diversion of auto trips to PRT, and the generation of trips by the PRT system.

METRIC CONVERSION FACTORS

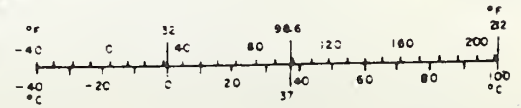
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.5	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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1. BACKGROUND

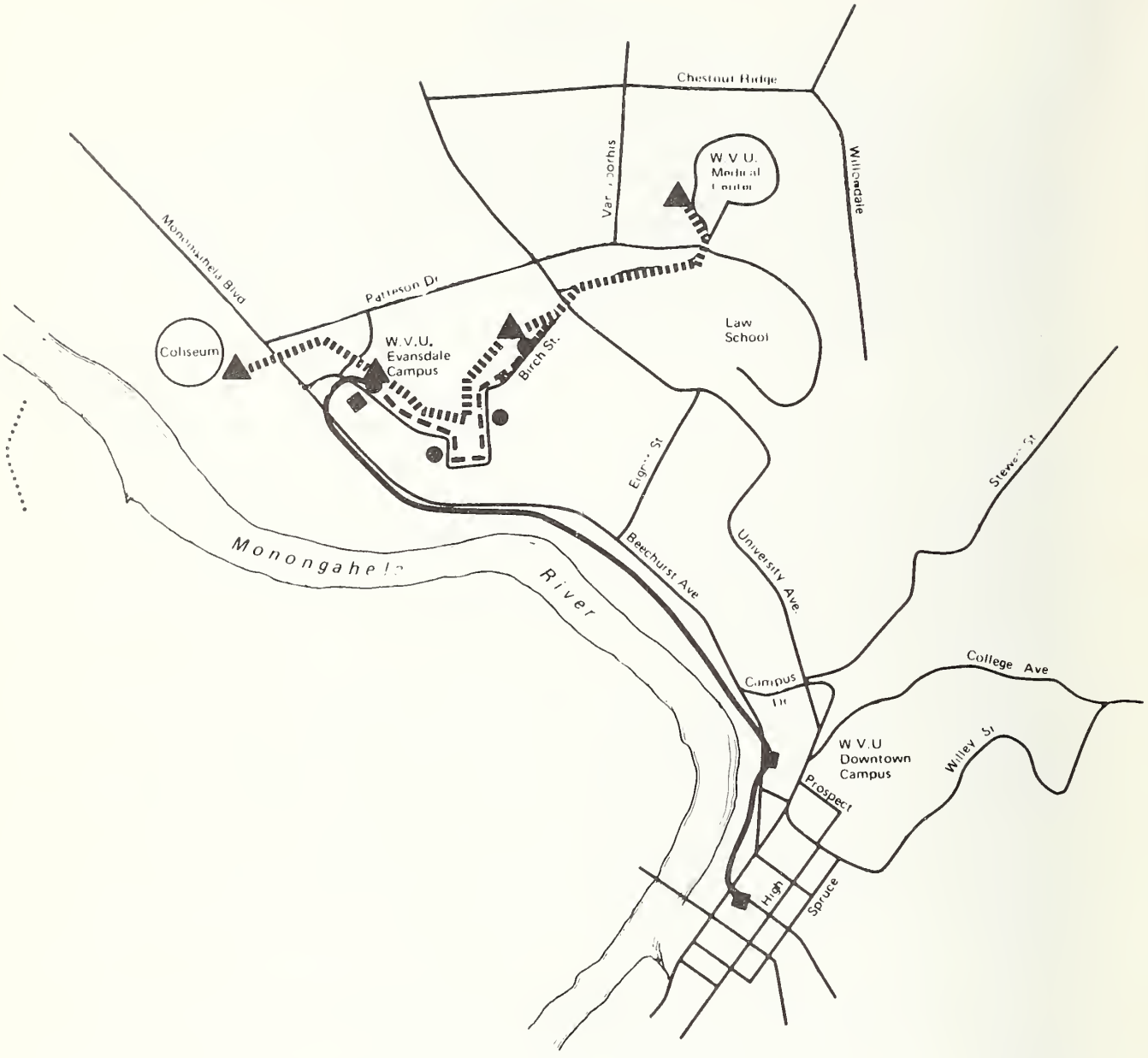
1.1 THE MORGANTOWN PRT SYSTEM

The Morgantown Personal Rapid Transit system currently has three stations, 2.1 miles of two-lane guideway, and a 45-vehicle fleet. The stations are Walnut, located in the downtown area of Morgantown; Beechhurst, on the main downtown campus; and Engineering, on the suburban or Evansdale campus of West Virginia University. As a result, this three-station system primarily serves intercampus trips.

The three-station system initiated PRT passenger service during October 1975. Passenger service was provided as part of the 1975-1976 year-long PRT operational testing program. During this operational testing program, PRT system operating characteristics varied as a result of problems the system had and as system availability increased. System operation improved as system improvements were tested and implemented.

The three-station PRT system represents Phase I of a proposed five-station PRT system (Phase II). The Phase I PRT system is composed of Phase IA and Phase IB. Phase IA was completed in 1972 with the construction of the three-station guideway, installation of a control system, and acquisition of five vehicles. In Phase IB, completed during the summer of 1975, a 45-vehicle fleet was delivered, operational testing was completed, and revenue passenger service began.

Construction of the Phase II PRT system will begin in the spring of 1977 and is expected to be completed and available for passenger service by September 1979. The Phase II PRT system will add two stations, and up to 33 additional vehicles, PRT vehicles, and control and power distribution systems. The additional stations at Medical Center and Towers will expand the PRT service configuration to provide downtown-to-Medical Center service, as well as intercampus service. It should be noted that the West Virginia University Medical Center, with its 600-bed hospital, is the major regional medical facility and a major employer for the area.



Legend: ■ PRT Stations; —— PRT route
▲ Stops, Bus Feeder Service between Medical Center and Coliseum; ▪▪▪▪ bus route
● Stops, Bus Feeder Service between Towers and Engineering; - - - bus route

FIGURE 1-1. ROUTES AND STOPS, PRT AND FEEDER SERVICE (OCTOBER 1975-JANUARY 1976)

1.2 INITIAL PRT PASSENGER SERVICE

During academic year 1975-1976, the Morgantown PRT system provided PRT passenger service on the three-station Phase IB system. Initial PRT passenger service was scheduled to provide weekday service during 13 hours from 7:30 a.m. through 8:30 p.m. beginning October 27, 1975. Weekend service was scheduled from 9:30 a.m. through 3:00 p.m. Saturdays and Sundays. However, the service operated was less than that scheduled. During the initial months of passenger service, the actual hours of operation were less than those scheduled because the system was experiencing winter problems and other start-up problems.

The coincidence of operational testing and passenger service caused the PRT service to vary in its reliability and in the number of hours it was available. It is necessary to measure the effect of differing levels of system availability and reliability to assess levels of PRT ridership in the 1975-1976 academic year.

1.3 PRT FEEDER SERVICE

When PRT passenger service was initiated in October 1975, the existing fleet of 15 West Virginia University campus buses was redeployed to provide feeder service to PRT stations. On any day, approximately 10 to 12 buses were in service. Additionally, when the PRT system was not operating, the bus fleet would provide substitute service to all locations on both campuses.

The campus buses provided feeder service to the PRT to complement PRT operation according to the two routes depicted in Figure 1-1. There was a feeder service, operating on 5-minute headways to the Engineering Station from Towers (a large undergraduate dormitory on the Evansdale campus) with stops at the Agricultural Sciences Building and Allen Hall. Additionally, there was a shuttle service operating on 15-minute headways between Coliseum and Medical Center, both of which have large parking lots, stopping en route at the Engineering PRT Station, Allen Hall, and the Towers dormitory.

When the PRT system experienced shutdowns, the campus bus fleet provided intercampus substitute service. Buses would leave from Campus Drive (downtown campus) at 5-minute headways for Evansdale Campus and Medical Center.*

When PRT service was introduced, no bus service was provided between PRT stations during the hours that the PRT system was operating. This arrangement meant that the bus did not compete with the PRT for riders during PRT operating hours. The University provided PRT feeder service from October 23, 1975, through January 28, 1976.

Increasingly wintery weather caused difficulties for the PRT's operation and resulted in route alterations to the bus feeder service. From January 29, 1976, through April 28, 1976, the bus service resumed its former service to all campus destinations which had existed for many years, prior to PRT passenger service. Figure 1-2 shows the route covered when the pre-existing intercampus bus service was resumed. However, the campus buses adapted the route to stop adjacent to two of the three PRT stations, rather than their former stops. For example, the bus stopped at the PRT Engineering Station rather than at the Engineering Building located across the road. The buses did not serve the downtown, off-campus, Walnut Street PRT Station.

The bus, therefore, operated competitively with the PRT. This route revision established the bus as a modal competitor to the PRT. It should be recognized that use of the PRT, under the competing bus situation, meant the passenger tolerated wait and possibly transfer time in order to ride the PRT for a portion of his trip.

This analysis is designed to use the shift in bus service to highlight PRT ridership patterns. PRT ridership, when there was only feeder service, represents the captive intercampus travel flow. PRT ridership with competing bus service represents choice travel between campuses.

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* "PRT Guide to Riding the Personal Rapid Transit System, Daily Atheneum, West Virginia University, October 3, 1975.

In summary, PRT passenger service during the academic year 1975-1976 is analyzed according to the two configurations of the bus service. The bus service between October and January is called "Feeder Service"; service between January and April is called "Competing Bus Service."

1.4 INTERIM ANALYSIS

This Interim Analysis monitors and analyzes ridership responses to the introduction of PRT passenger service. Because the introduction of passenger service occurred simultaneously with the PRT system's operational testing program, the Interim Analysis examines initial ridership response in relation to the varying levels of system operation occurring at this time.

Recognizing the shift in feeder service, the design of the Interim Analysis focuses on comparison of two time periods: October 23, 1975, through January 28, 1976 which represents PRT operation with campus bus feeder service; and January 29 through April 28, 1976, when PRT operated simultaneously with a competing bus service which served many of the same destinations.

The structure of the Interim Analysis is as follows:

a. Description of PRT ridership as it evolved during academic year 1975-1976.

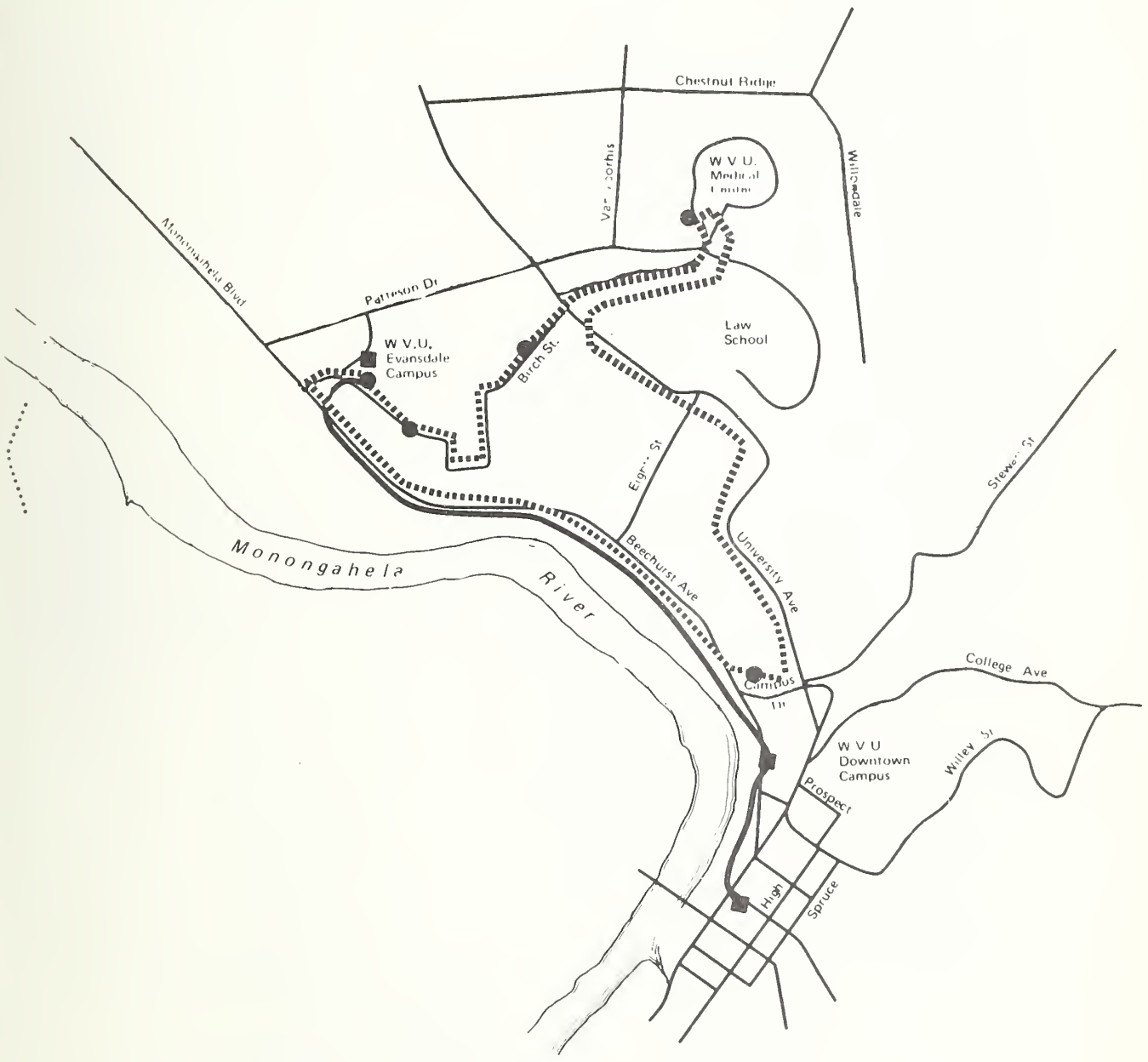
b. Weekly trends in PRT ridership, including the influence of exogenous events.

c. PRT ridership as affected by altered feeder service.

d. The impact of system operating characteristics on PRT ridership.

The Interim Analysis is a component of the ongoing, multi-year Morgantown PRT Impact Evaluation. The Impact Evaluation has been developed to measure public acceptance of a fully automated Personal Rapid Transit system and to determine the eventual applicability of such a system. The primary components of the Impact Evaluation record conditions prior to and following PRT revenue service.

Table 1-1 places the Interim Analysis within the Morgantown PRT Impact Evaluation and the transportation services offered.



Legend: ■ PRT stations; ——— PRT route
● Stops, Competing Inter-Campus Bus Service
▪▪▪▪▪▪▪▪▪ bus route

FIGURE 1 2. ROUTES AND STOPS, PRT AND COMPETING BUS SERVICES (JANUARY-APRIL 1976)

TABLE 1-1. MORGANTOWN PRT SYSTEM SERVICE AND PRT IMPACT EVALUATION

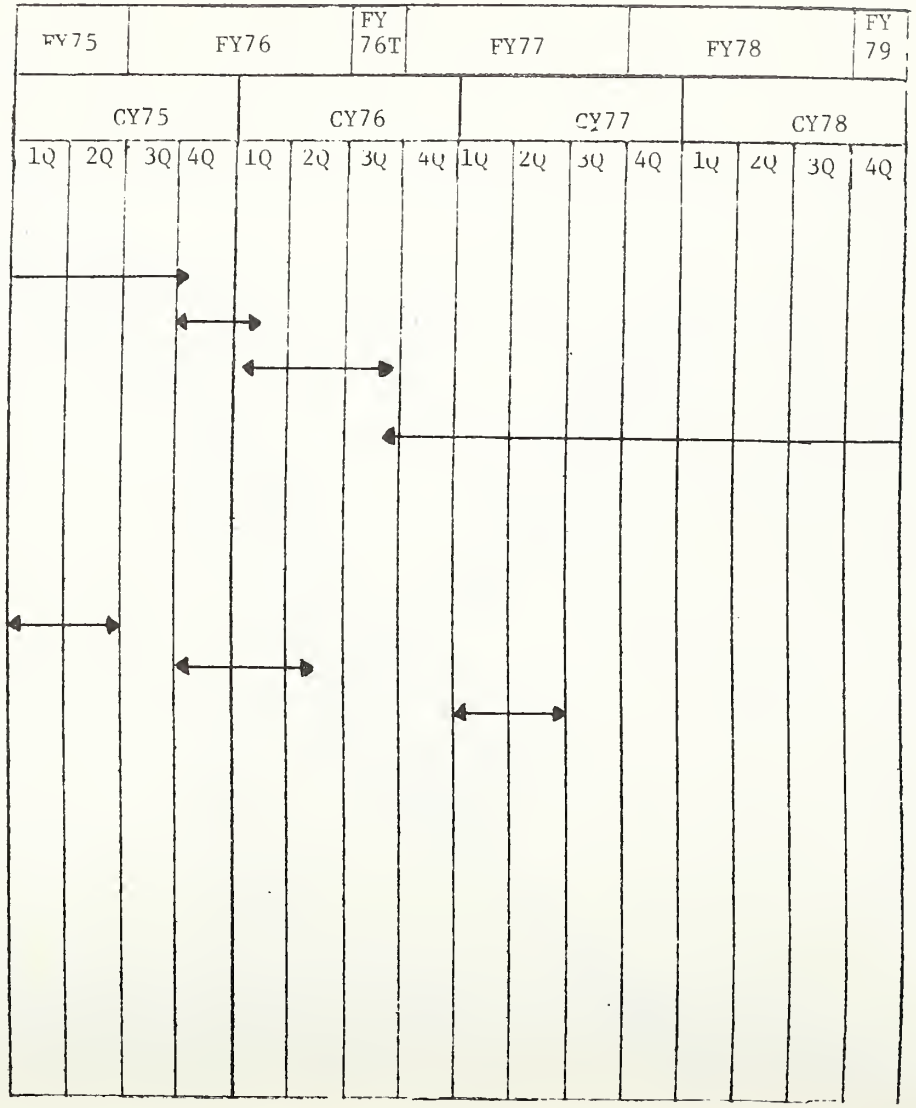
TRANSPORTATION SERVICE

- Bus Service Only
- PRT Passenger Service with Feeder
- PRT Passenger Service with Competing Bus
- PRT Revenue Service

PRT IMPACT EVALUATION

Data Collection for

- Pre-PRT Phase
- Interim Analysis
- Post-PRT Phase



2. PRT RIDERSHIP

2.1 OVERVIEW

This section describes PRT ridership in two ways: mean daily ridership and weekly ridership trends. Mean daily ridership is presented for the academic year 1975-1976 as influenced by the feeder service, intra-week variation, and fare structure.

The following table summarizes the data presented on daily PRT ridership in Section 2.2.

PRT RIDERSHIP

	MEAN DAILY RIDERSHIP	INTRAWEEK RIDERSHIP	FARE CATEGORY
1975-1976 Academic Year	Figs. 2-1 & 2-2	Fig. 2-3	Fig. 2-4
By Type of Bus Service	Figs. 2-5 & 2-6	Fig. 2-7	Fig. 2-8

The second way to examine PRT ridership focuses on weekly trends in PRT ridership. Weekly trends reveal the development of incremental ridership as well as the impact of exogenous or university-calendar influences on emerging PRT ridership trends. The figures in Section 2.3 explicitly reference notable exogenous events in relation to the PRT ridership trend.

2.2 DAILY RIDERSHIP

PRT ridership is measured as total mean daily passengers during the 1975-1976 academic year. Additionally, the influence of the alternative PRT feeder service is presented. Daily ridership is discussed in three ways:

a. Daily mean, maximum, and minimum ridership;

b. Intra-week ridership which specifies ridership for average Mondays, Tuesdays, etc. Because a university activity pattern typically follows an alternate-day class schedule, day-to-day continuity cannot be assumed;

c. Fare structure which is a proxy way to measure student versus non-student PRT ridership. During 1975-1976, West Virginia University students paid a transportation fee of $10 per semester upon registration and were issued PRT passes. Although passes were available to others for the same fee, most non-student users paid a one-time fare of 25¢.

2.2.1 1975-1976 Morgantown PRT Ridership

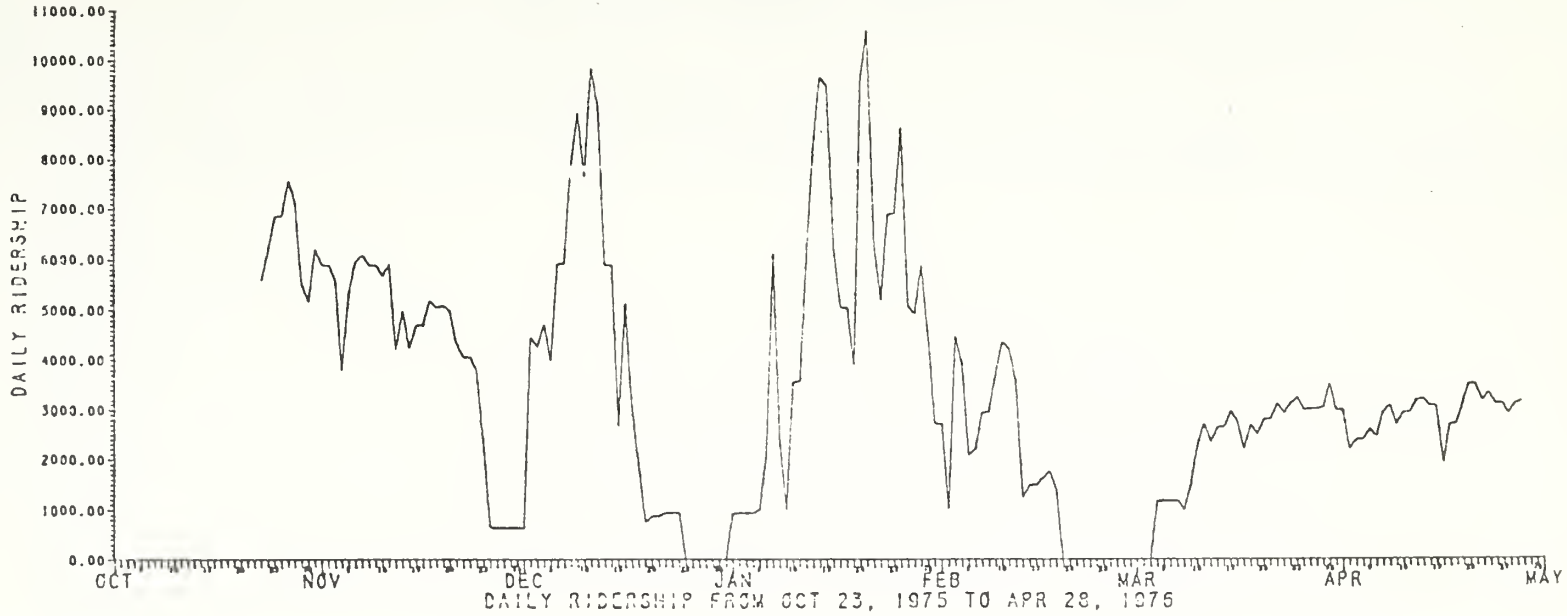
Mean daily PRT ridership during academic year 1975-1976 was 3,303, with a maximum of 10,588 and a minimum of 88 riders. Alteration in the bus service lowered mean daily ridership levels during the second semester from 4,220 to 2,295 (see Appendix A).

It is useful to delete weekends and university vacations, due to the reduced operating hours in the former case, and lack of demand in the latter case. With these deletions mean daily PRT ridership was 4,203, with a high of 10,588, and a minimum weekday ridership of 627 (see Figure 2-1).

Examining weekend usage during the 1975-1976 academic year shows a mean daily ridership of 811 with a high of 2,414 and a low of 88 passengers (see Figure 2-2).

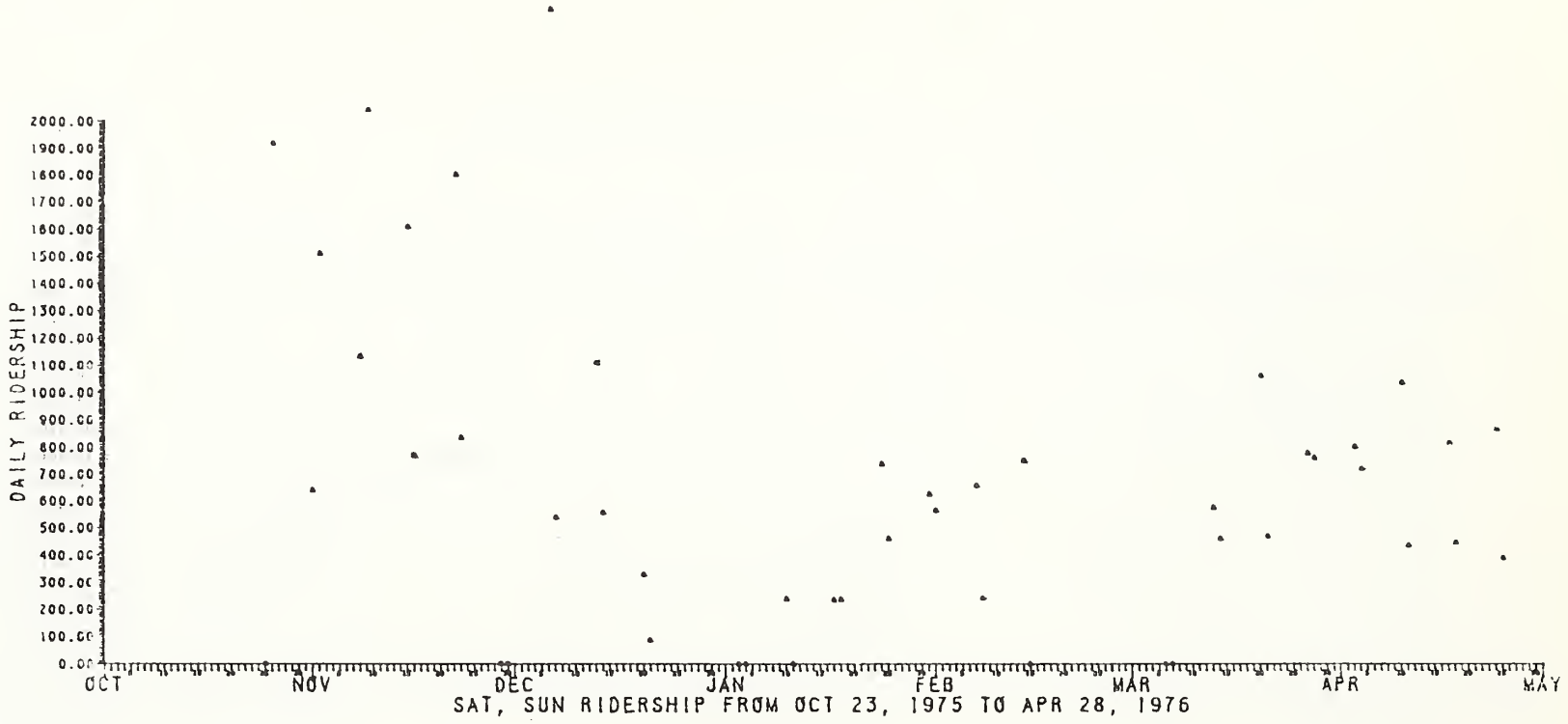
It is necessary to examine PRT ridership by day of the week because in a university each day has a distinct schedule. During the 1975-1976 academic year, the highest mean daily ridership occurred on Thursdays when the PRT system carried an average of 4951 riders. Fridays had the lowest weekday average ridership of 3,762 (see Figure 2-3).

Ridership by fare category, a proxy for user characteristics, shows that student use (multiple fares) far surpassed non-student use (single fares). Student use averaged 3,083 riders per day. It is interesting to note that, following the end of spring break



This figure contains weekday ridership only; weekend ridership is estimated as the mean daily ridership on the nearest Friday and Monday.

FIGURE 2-1. 1975-1976 PRT DAILY RIDERSHIP: WEEKDAYS ONLY



This figure presents ridership for each Saturday and Sunday; weekday ridership is omitted.

FIGURE 2-2. 1975-1976 PRT WEEKEND RIDERSHIP

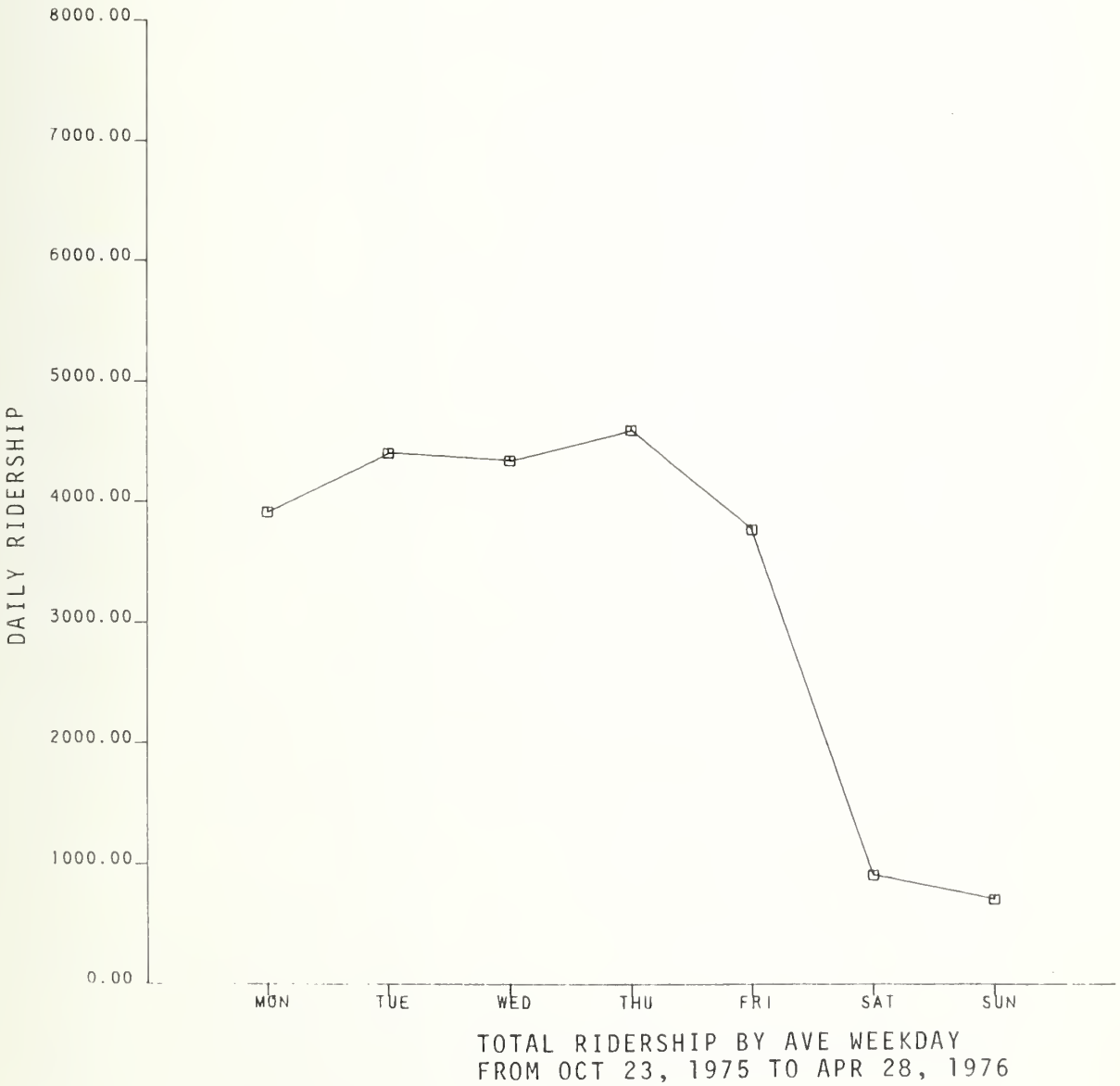


FIGURE 2-3. PRT RIDERSHIP BY DAY OF WEEK

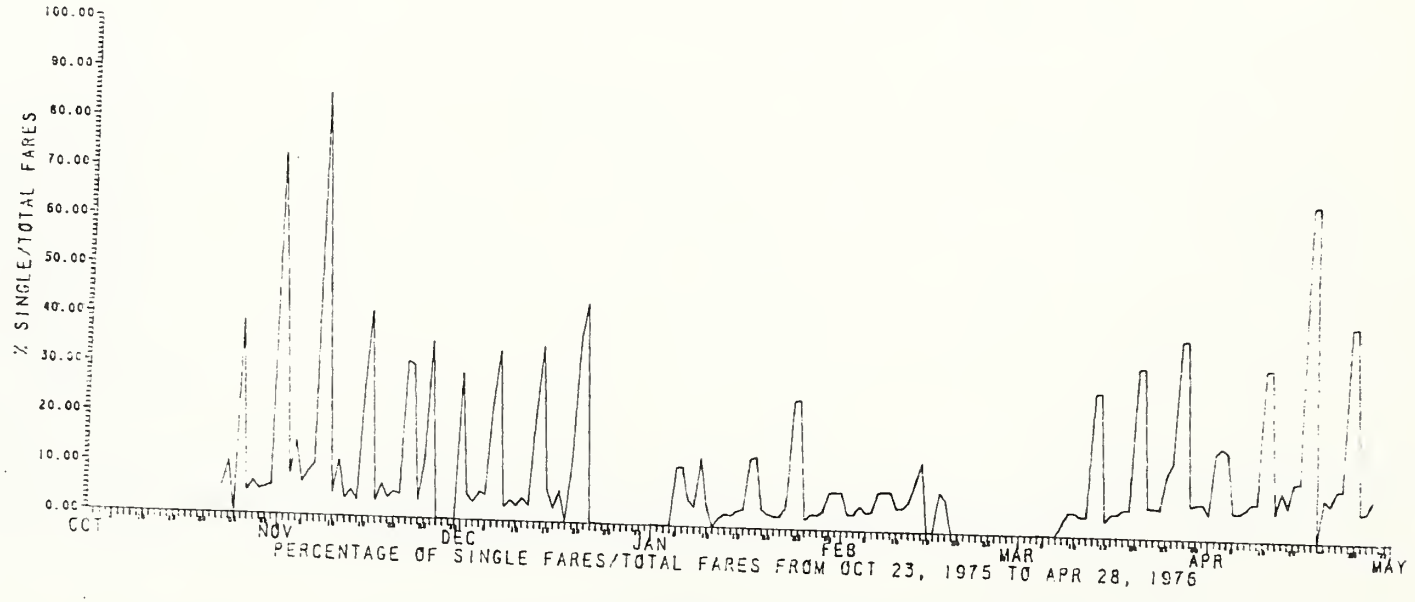


FIGURE 2-4. PRT RIDERSHIP BY FARE CATEGORY (OCTOBER 23, 1975 - APRIL 28, 1976)

(March 7, 1976), student use gradually increased (see Appendix A).

Non-student ridership did not vary as much as student ridership. Mean daily non-student use is 246 passengers. Figure 2-4 shows that on weekends single fares averaged 40 percent of total ridership, whereas on weekdays non-student ridership represented 5 percent of the totals.

2.2.2 Feeder Service and PRT Ridership

Recognizing the PRT feeder service alteration which began on January 29, 1976, and lasted throughout the spring, it is illustrative to compare ridership under the differing feeder service conditions described in Section 1. It is assumed that there were no alternatives to the fall semester's PRT feeder service and that the spring semester's competing bus service enabled the rider to choose between the PRT and the campus bus.

Ridership volumes are compared for the alternative PRT feeder services. Figures 2-5 through 2-8 show ridership under both conditions to highlight the impact of the alternative feeder services.*

When there was PRT feeder service, PRT ridership climbed rapidly in early November, and decrased around the Thanksgiving recess. Ridership peaked again just before the Christmas recess. January showed increasing PRT ridership. Average daily ridership while there was PRT feeder service was 4220, with a peak of 10,588 and a low of 88.

After conversion to the competing bus service, PRT ridership dropped off rapidly. Following the spring break in early March, PRT ridership increased steadily during the remainder of the semester. Mean daily ridership was 2,295, 55 percent of the mean ridership during the earlier period. Maximum daily ridership was 5,867, 55 percent of the earlier peak and averaged 3,100 on days when the system operated for at least 12 hours. The minimum daily ridership was 243.

*Statistical tests of significance between ridership levels by feeder service are described in Appendix C.

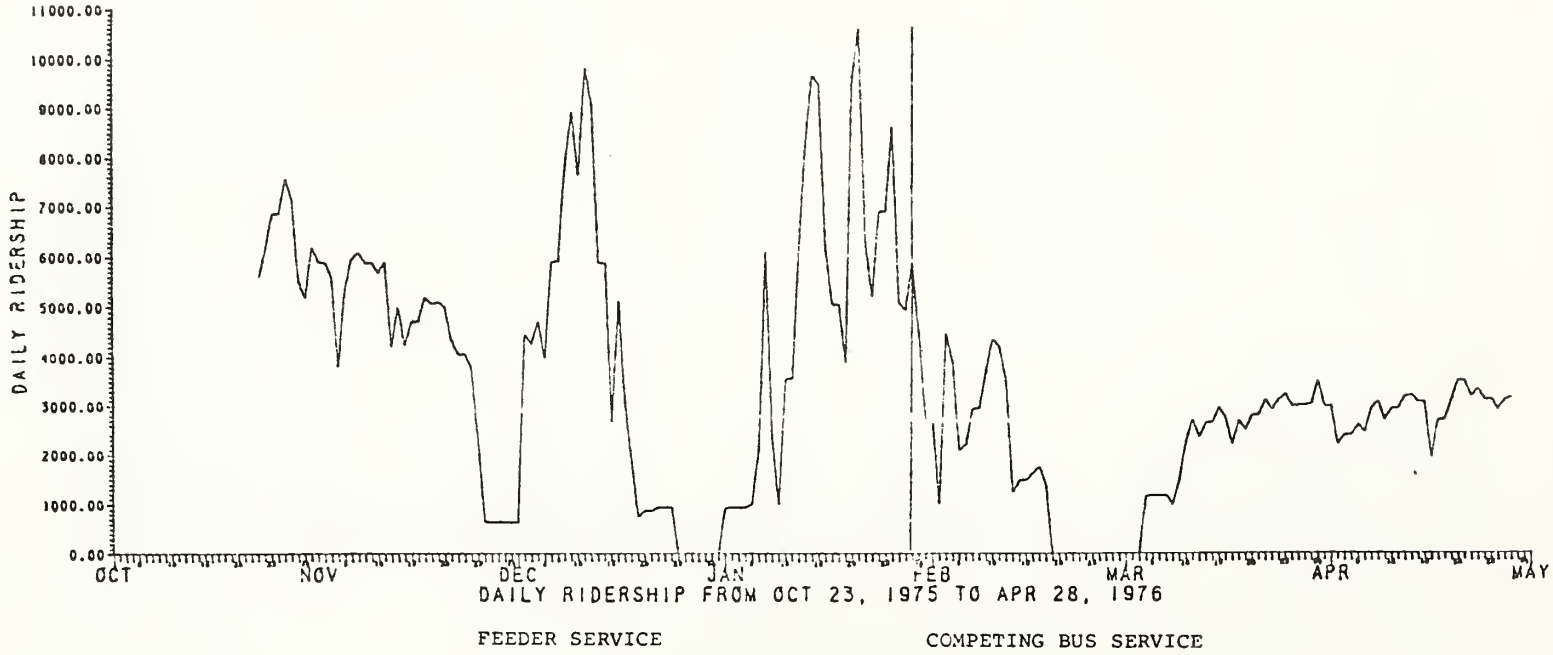
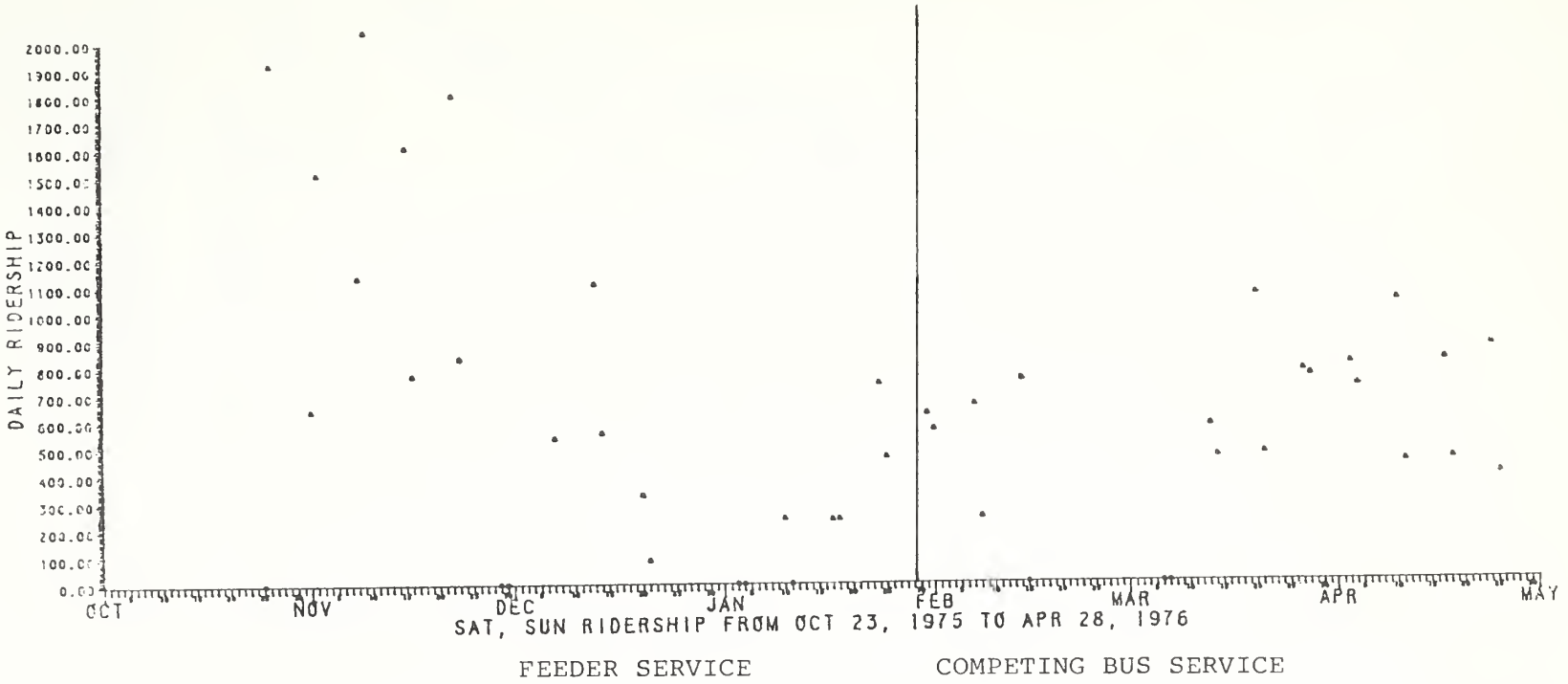


FIGURE 2-5. 1975-1976 PRT DAILY RIDERSHIP BY FEEDER SERVICE: WEEKDAYS ONLY



This figure presents ridership for each Saturday and Sunday; weekday ridership is omitted.

FIGURE 2-6. 1975-1976 PRT WEEKEND RIDERSHIP

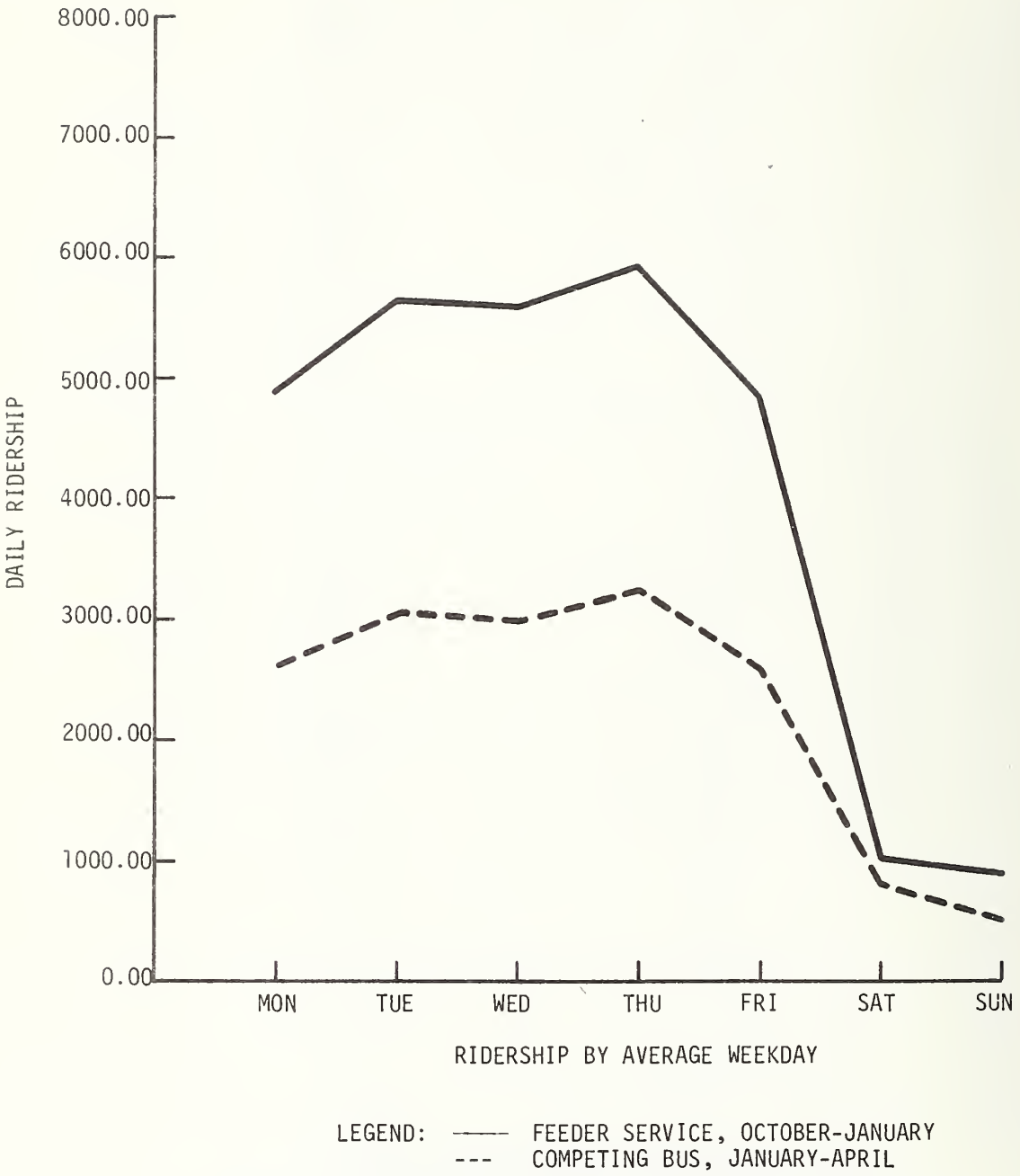


FIGURE 2-7. PRT RIDERSHIP BY DAY OF WEEK BY FEEDER SERVICE

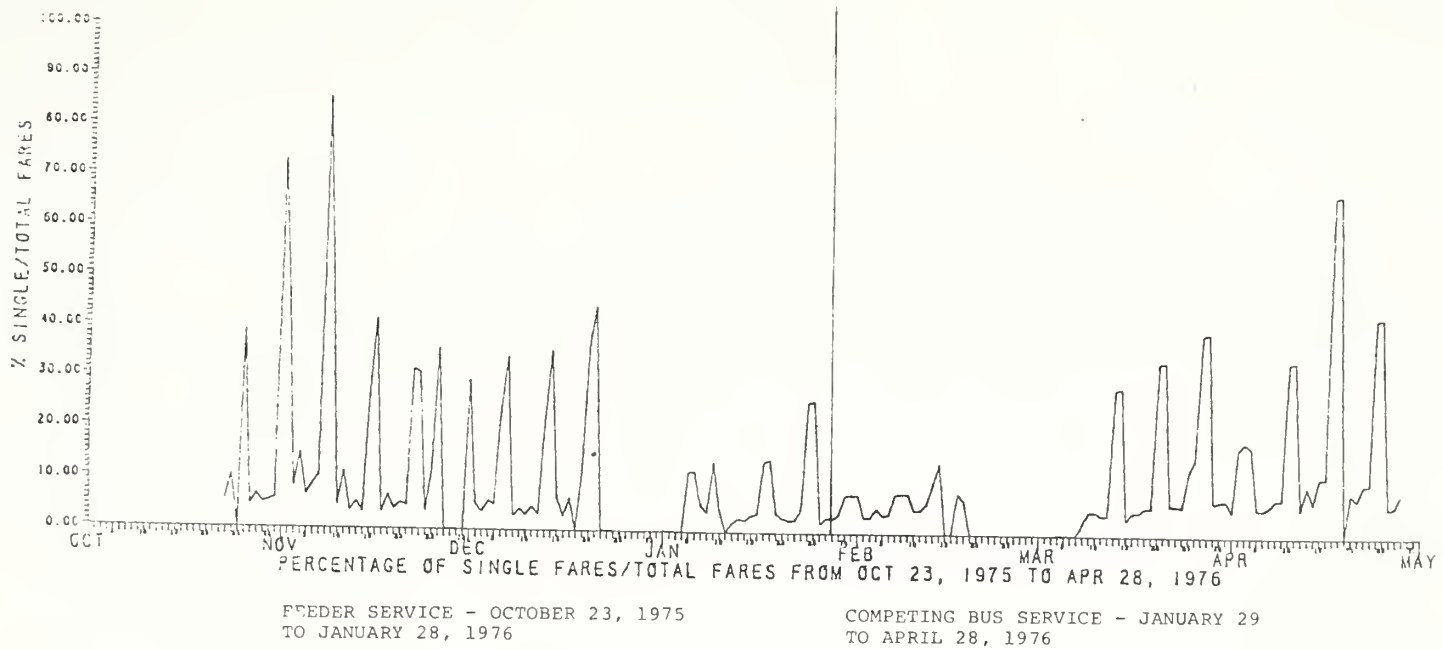


FIGURE 2-8. PRT RIDERSHIP BY FARE CATEGORY AND FEEDER SERVICE

However, there was no significant difference in mean ridership levels on Saturdays and Sundays with differing feeder services. Thus, statistically, there were similar weekend use-levels throughout the 1975-1976 academic year. Weekend travel is likely to be for discretionary purposes. The continuing similarity of weekend PRT travel volumes reveal the utility of the PRT for such purposes. (Figure 2-6).

PRT ridership by day of the week had a similar profile during both feeder service configurations. Peak ridership occurred on Thursdays, 5,934 and 2,984; and lowest ridership occurred on Sundays. (Figure 2-7).

The distribution of PRT ridership throughout the five-day week shows the relative level of use remained the same, despite a decline in volume as shown in the following table.

Weekday	PRT FEEDER SERVICE (October-January)		COMPETING BUS SERVICE (January-April)	
	Total Ridership	Proportion (Percent)	Total Ridership	Proportion (Percent)
Monday	58,331	19	23,541	16
Tuesday	67,945	23	33,591	23
Wednesday	66,751	22	32,803	22
Thursday	59,341	19	32,487	22
Friday	53,173	17	25,831	17
Total	305,547	100	148,253	100

The similar distribution of weekday PRT ridership suggests that the PRT modal split is not determined by daily course assignments or the university calendar. It is likely that individual modal choice contributed to the similarity in this distribution.

Analysis of ridership by fare category, which represents student versus non-student ridership, shows that student ridership declined 48% due the changed feeder service. Mean daily student ridership declined from 3981 to 2095 during the period of competing bus service.

Non-student PRT ridership declined relatively less, averaging 246 and peaking at 967 in November 1975, when many used the PRT to attend university athletic events. Daily non-student ridership during the period of competing bus service declined only 20 percent, peaked at 553 and averaged 199.

In interpreting the smaller decline in non-student ridership during the 1975-1976 academic year, it must be noted that these riders generally were not eligible to use the PRT bus services which required a pass. The decline, based on avarage non-student ridership during the two time periods, represents the impact of the winter weather on PRT system operation (see Figure 2-8).

2.2.3 Summary

PRT ridership in 1975-1976 had the following characteristics:

a. Mean daily ridership was 3,303; excluding weekends and university vacations, mean daily ridership was 4,203.

b. Mean daily ridership was 4,220 with PRT feeder service; 2,295 with competing bus service: a 45 percent decline.

c. Mean daily ridership was highest on Thursdays (4,591) and lowest on Sundays (707). Thursday ridership averaged 5,934 with a feeder service; 2,894 with a competing bus service: a 51 percent decline in volume on Thursdays. Sunday ridership averaged 894 with a feeder service; 498 with a competing bus service: a 38 percent decline.

d. Mean daily student ridership ("multiple fares") was 3,083. Mean daily student ridership with a feeder service was 3,981; 2,095 with a modal competitor service: a 48 percent decline.

e. Mean daily non-student ridership ("single fares") was 246. Mean daily non-student ridership with a feeder service was 289; 199 with competing bus service.

It is necessary to view PRT ridership volumes in terms of the feeder service offered. While the campus bus operated as a PRT feeder only during the fall, the PRT served all student, non-auto, trips between its three stations. Maximum ridership volumes during the fall represent the student travel-demand at that time.

However, with the realignment of the campus bus to provide campus-wide service as well as service to PRT stations, the student chose between travel on one vehicle to his destination versus transfer- and wait-time to board a PRT vehicle. The 45 percent decline in PRT ridership, when the bus provided competing service, highlights the attractiveness of the PRT, which was deliberately selected for its qualities relative to the bus.

2.3 RIDERSHIP TRENDS

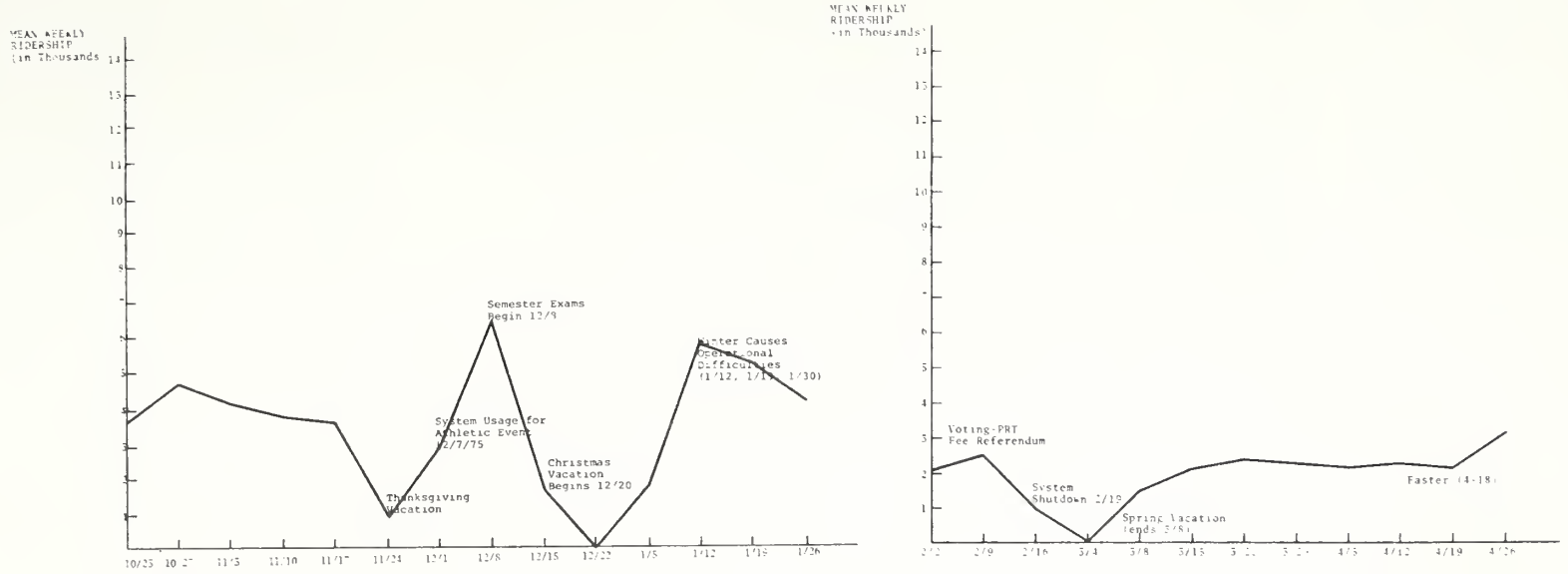
PRT ridership was examined to determine how it varied on a weekly basis throughout the 1975-1976 academic year. Average daily ridership per week was examined in terms of trends and the occurrence of exogenous events. Ridership is expected to increase in weekly increments as riders and potential riders became more familiar with this radically new transportation alternative.

2.3.1 Weekly Trends

Average daily ridership per week was quite variable through January 28, 1976. A review of exogenous events occurring during this time accounts to some degree for the marked differences. Thanksgiving occurred during the week of 11/24 and the PRT system was shut down for four days to permit staff vacations. On Saturday, 12/7, the PRT system operated between 7 and 10 p.m. to carry people to the basketball game. Final exams during the weeks of 12/8 and 12/5 caused more irregular and infrequent student travel on campus. Christmas vacation officially began 12/20/75 and lasted until 1/4/76 (see Figure 2-9).

Following a ridership peak during the week of 1/12/76, the beginning of the semester, the PRT had difficulty operating in the winter climate, particularly on 1/12, 1/16 and 1/30. This resulted in decreased system reliability, fewer operating hours, and therefore, ridership declines.

In order to compensate for the service degradation due to climate, on January 29, 1976, the campus bus was realigned to provide full coverage service to all points on the campus.



Feeder Service

Competing Bus Service

FIGURE 2-9. PRT RIDERSHIP TRENDS

During the week of 2/2 the students voted negatively on a referendum to increase their transportation fee from $9 to $25 per semester. This increase was requested to meet estimated PRT operating and maintenance costs during the academic year 1976-1977.

Winter weather problems again caused a system shutdown from 2/19 through the spring vacation. The PRT system resumed operation on 3/8/76.

System ridership was remarkably stable during March and April. There was a slight decrease during the week of April 12, 1976, the last week of classes during the spring semester.

2.3.2 Summary

Examination of weekly ridership trends reveals the following:

a. PRT weekly ridership was more variable during the fall semester than the spring semester.

b. Events on the university calendar account for much of the ridership variability between weeks.

c. Between March 8 and April 28, 1976, when the university schedule and PRT operations were both quite routine, PRT ridership was very stable, averaging around 2,500 riders per average day per week.

3. INFLUENCE OF PRT SYSTEM OPERATIONS ON RIDERSHIP

3.1 OVERVIEW

Section 3 relates PRT ridership to system operation to assess how operational features influenced ridership. System operation is measured by seven variables and the influence of each on ridership is analyzed separately as well as in combination. System operating characteristics during academic year 1975-1976 are described in detail in Appendix A.

The influence of PRT system operation on ridership is presented in three different ways to reveal the influences of system operation on ridership:*

a. Depiction of the chronological evolution of ridership with each of the seven system operating characteristics. These analyses show the emerging dependence or independence of ridership in relation to system characteristics.

b. Examination of the individual influences of each of the seven system operating characteristics (system availability, downtime deviation, downtime frequency, actual operating hours, and fleet mileage) on ridership.

c. Estimation of the simultaneous influence of all seven system operating characteristics on ridership.

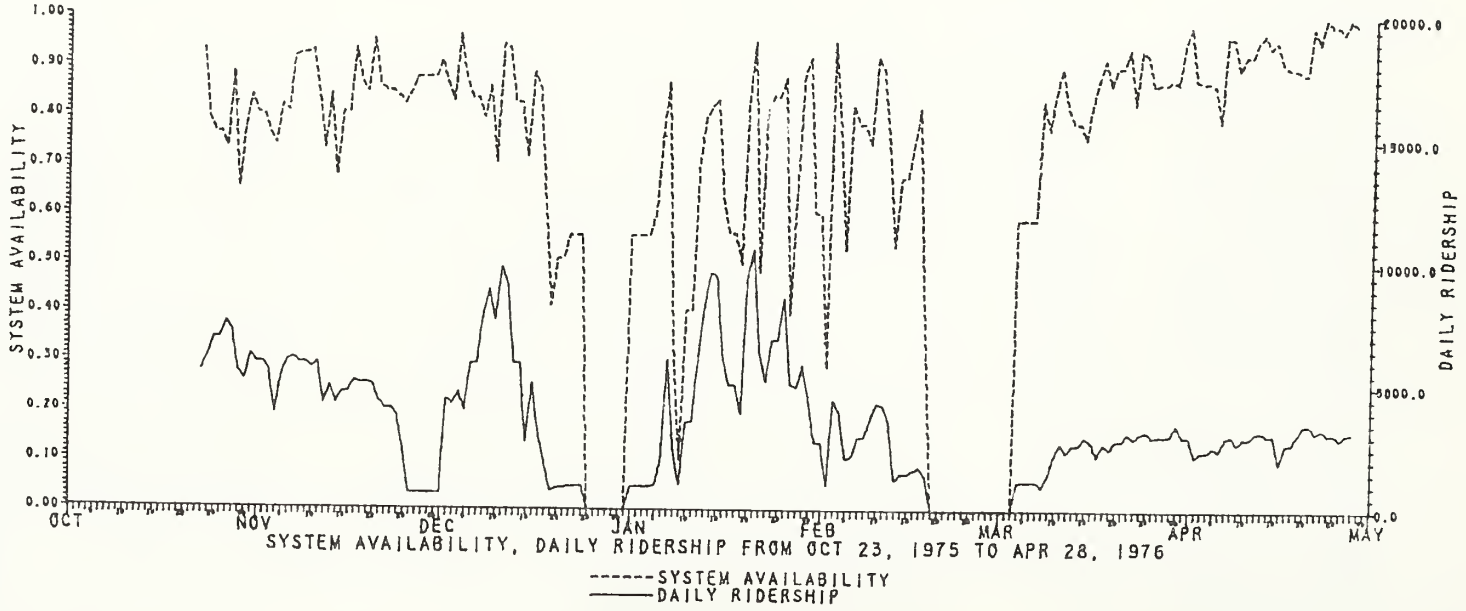
PRT ridership is presented according to the two distinct time segments used to describe ridership volume in Section 2: PRT feeder service (October 27, 1975 - January 28, 1976) and competing bus service (January 29, 1976 - April 28, 1976).

3.2 INFLUENCE OF PRT SYSTEM OPERATING CHARACTERISTICS ON RIDERSHIP

3.2.1 Chronological Influence of System Operating Characteristics

Ridership volume per day and each of the seven system operating characteristics were plotted graphically for the 1975-1976 academic year. These double graphs show simultaneous shifts

*The text in Section 3 summarizes many statistical analyses. See Appendix C for presentation of the graphic and statistical results; this material references relevant subsections in Section 3.



This and the subsequent six figures contain system operating characteristics and ridership only for weekdays; weekend levels are estimated as the mean daily level on the nearest Friday and Monday.

FIGURE 3-1. PRT RIDERSHIP AND PRT SYSTEM OPERATING CHARACTERISTICS

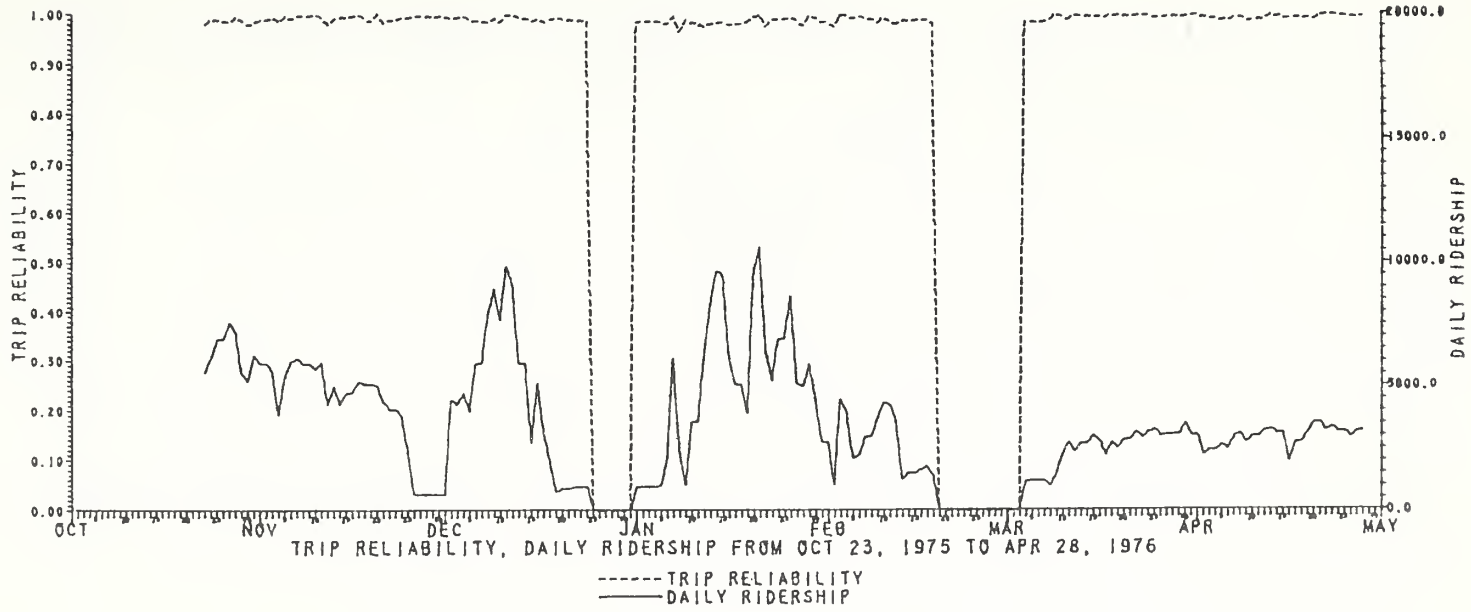


FIGURE 3-1. PRT RIDERSHIP AND PRT SYSTEM OPERATING CHARACTERISTICS (CONTINUED)

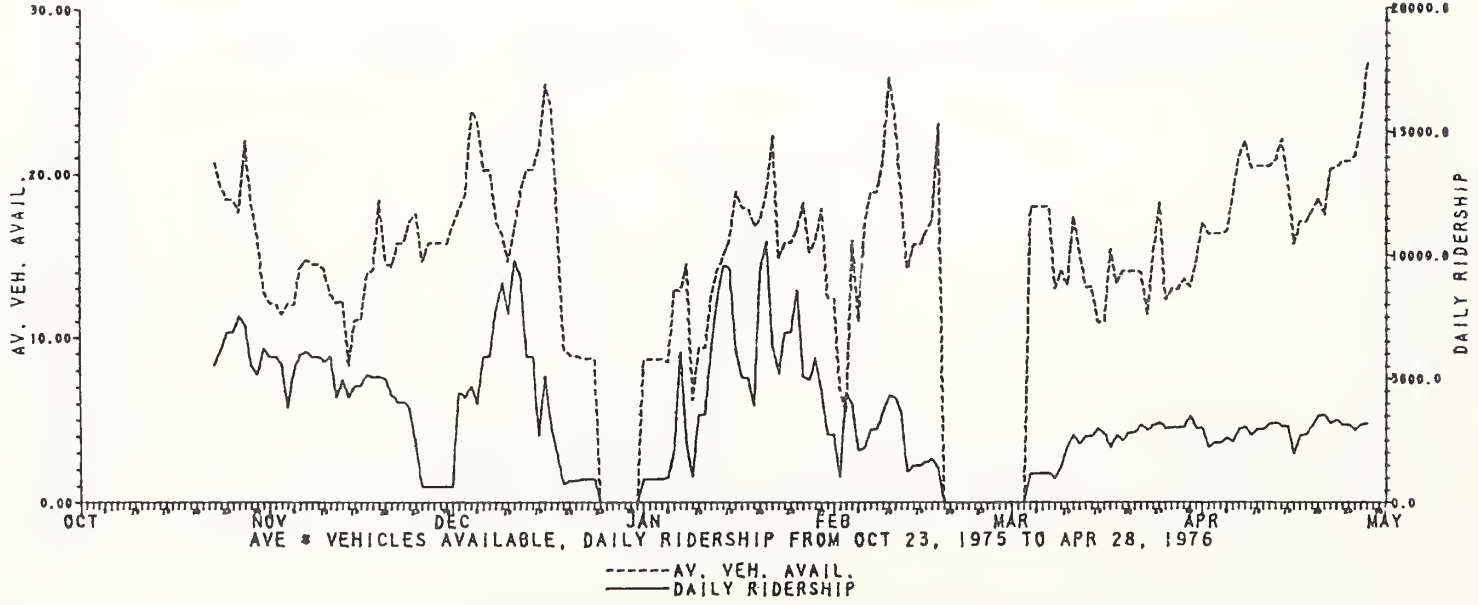


FIGURE 3-1. PRT RIDERSHIP AND PRT SYSTEM OPERATING CHARACTERISTICS (CONTINUED)

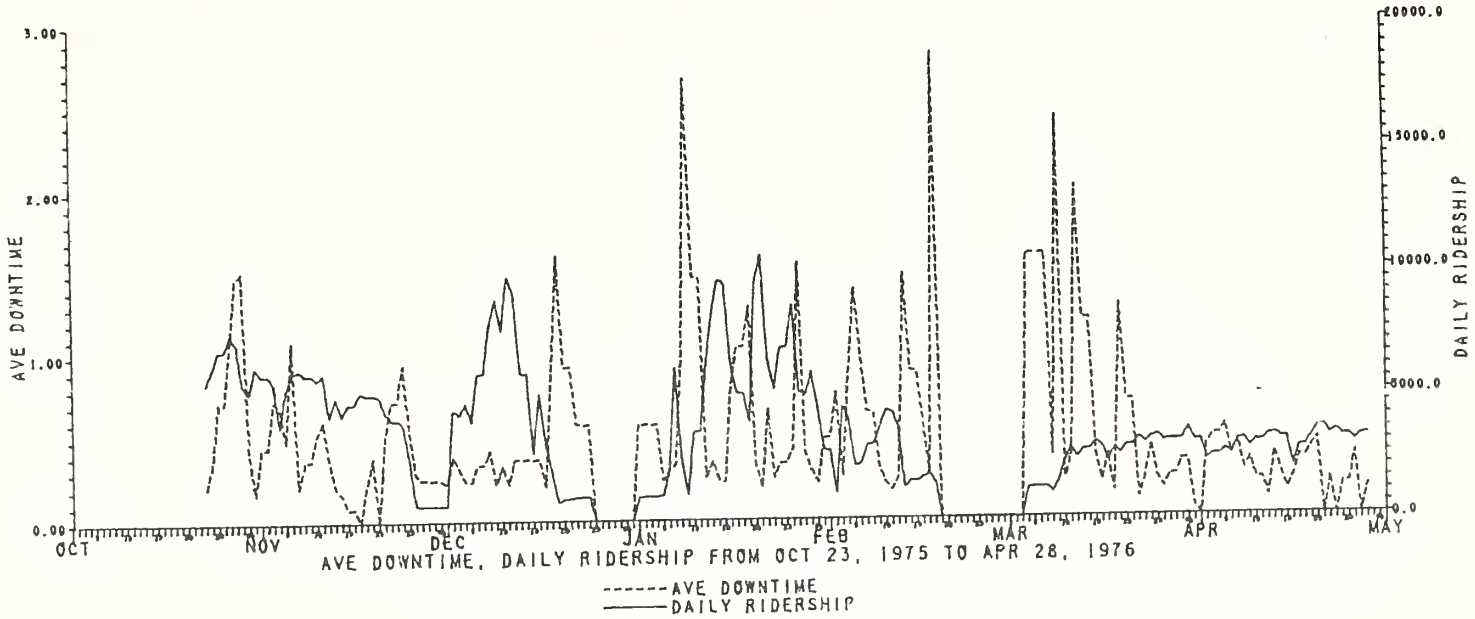


FIGURE 3-1. PRT RIDERSHIP AND PRT SYSTEM OPERATING CHARACTERISTICS (CONTINUED)

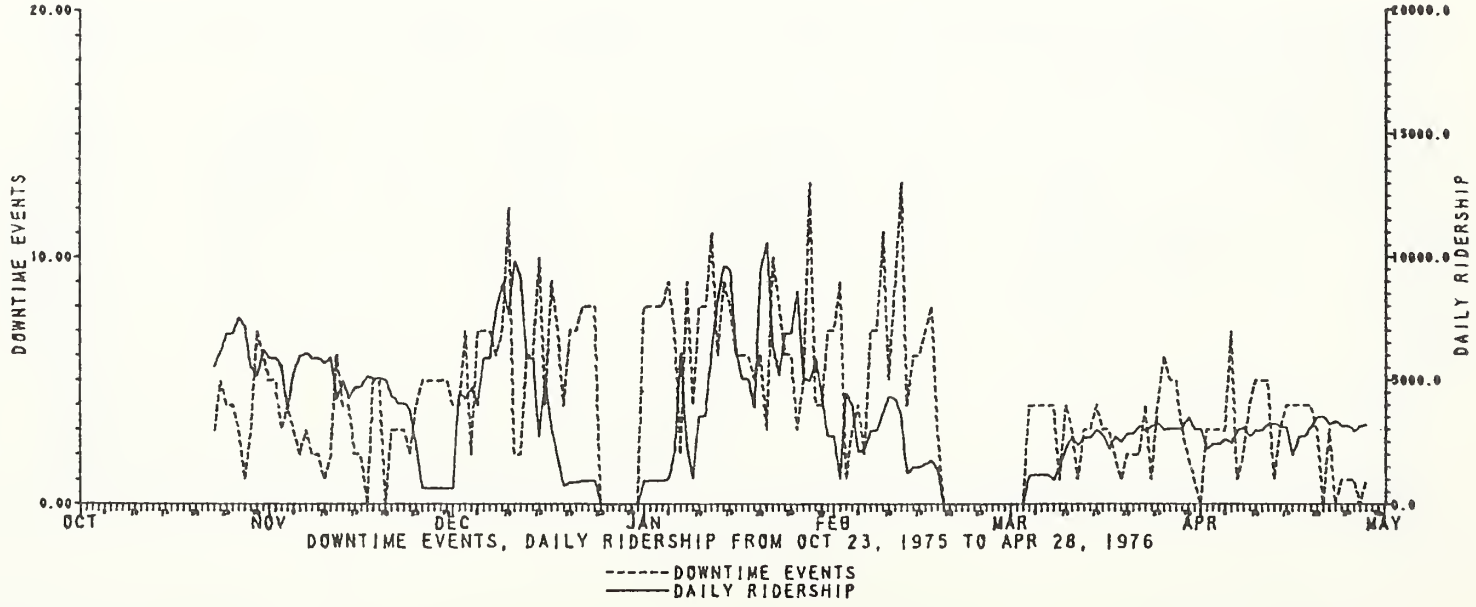


FIGURE 3-1. PRT RIDERSHIP AND PRT SYSTEM OPERATING CHARACTERISTICS (CONTINUED)

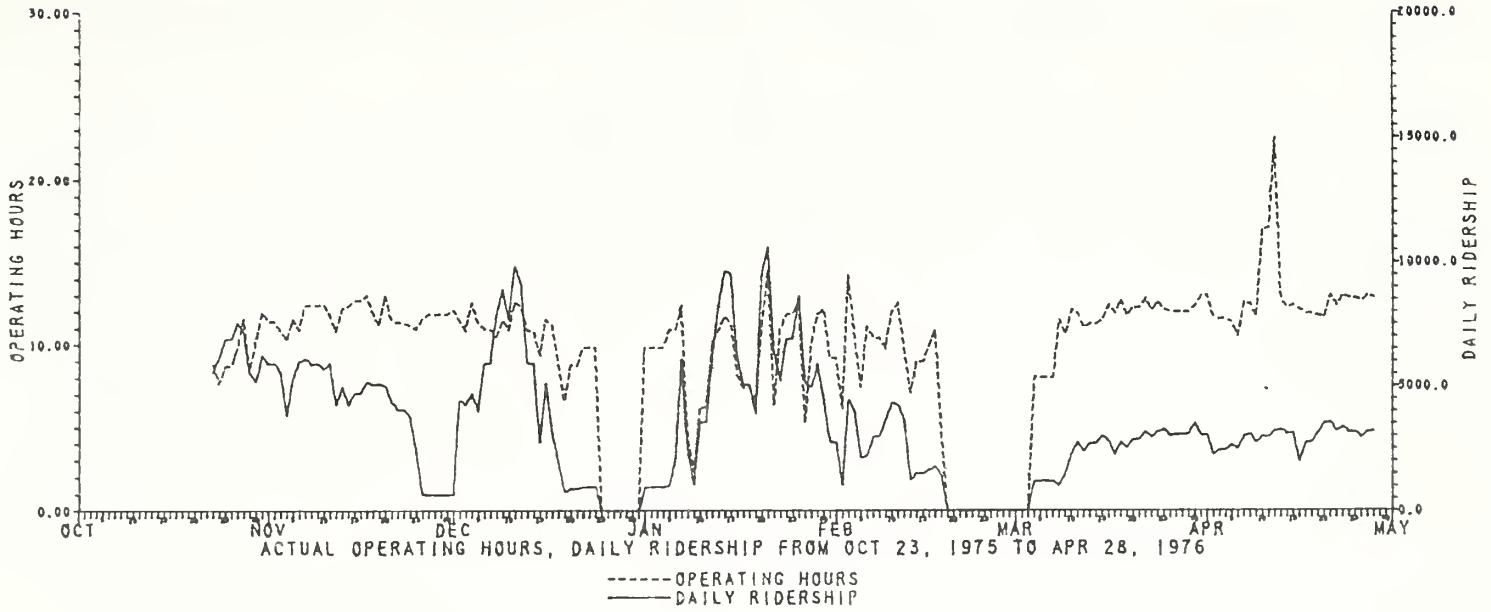


FIGURE 3-1. PRT RIDERSHIP AND PRT SYSTEM OPERATING CHARACTERISTICS (CONTINUED)

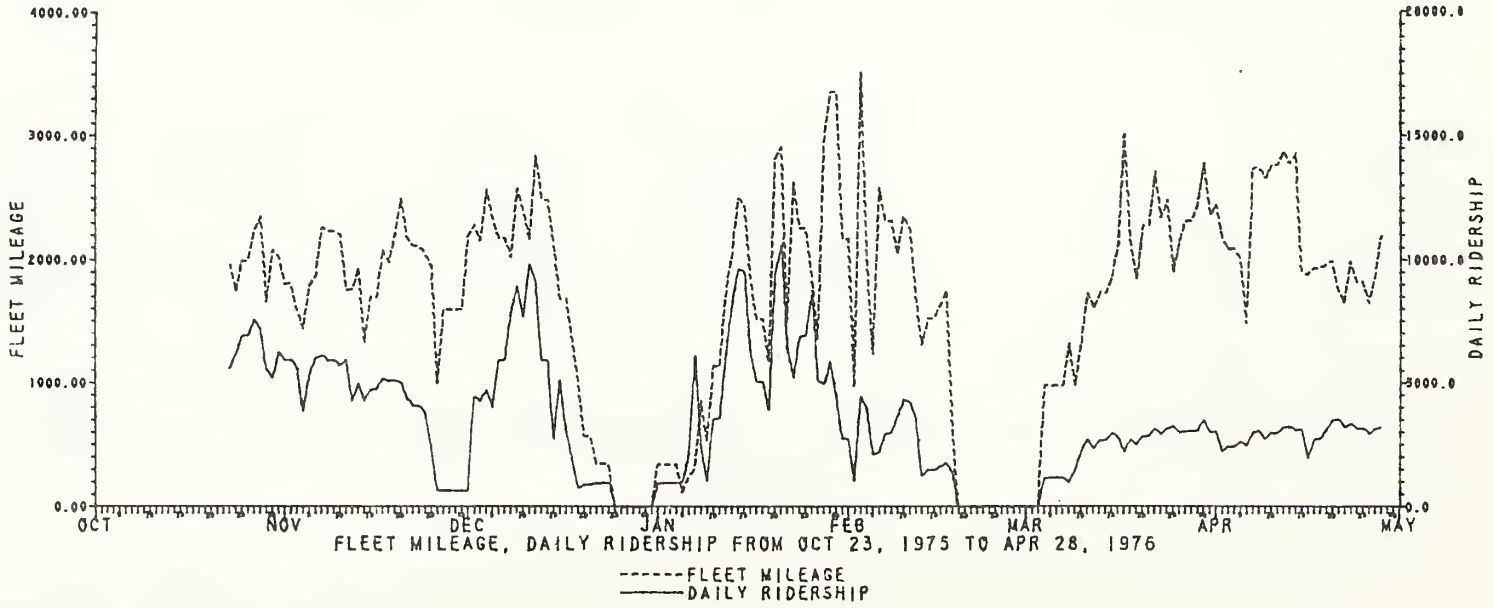


FIGURE 3-1. PRT RIDERSHIP AND PRT SYSTEM OPERATING CHARACTERISTICS (CONCLUDED)

in both ridership and system operating characteristics (see Figure 3-1). The following trends are apparent:

a. System availability achieved constant levels during spring 1976. Ridership also demonstrates less variability, although volumes were lower.

b. Trip reliability increased throughout the academic year, and by spring, had little variation. This corresponds with decreased intra-week ridership variation.

c. Vehicle availability varied markedly throughout the academic year. However, ridership most closely paralleled vehicle availability during the weeks of December 8, and January 12 and 19, periods of harsh weather when there was PRT feeder service.

d. Suprisingly, ridership volume showed no parallels with average length of downtime per day. However, ridership does parallel, in an inverse manner, the daily number of downtime events during both types of feeder service.

e. Excluding days just prior to and following university vacations, ridership varies with actual operating hours, particularly during December and January. The relationship is obscured in February, following revision of the feeder service, but becomes apparent after spring vacation.

f. Ridership appears to parallel closely fleet mileage. The period of PRT feeder service shows the volatility of both these measurements, whereas the competing bus service period shows the emergence of a more stable relationship between ridership and and fleet mileage.

3.2.2 Individual Influences of System Operating Characteristics

All the system operating characteristics have statistically significant relationships with ridership during both feeder services, except for downtime duration during competing bus service. Statistical analyses reveal that the likelihood of these relationships occurring by chance alone is 5 percent of the time (see Table 3-1).

TABLE 3-1. CORRELATION COEFFICIENTS BETWEEN PRT RIDERSHIP AND PRT SYSTEM OPERATING CHARACTERISTICS

PRT SYSTEM OPERATING CHARACTERISTICS	PRT RIDERSHIP WITH BUS FEEDER SERVICE	PRT RIDERSHIP WITH COMPETING BUS SERVICE
Fleet Mileage[a]	.83	.87
Actual Operating Hours[b]	.79	.84
System Availability[c]	.62	.46
Trip Reliability[d]	.49	.48
Vehicle Availability[e]	.46	.37
Downtime Frequency[f]	.39	.43
Downtime Duration[g]	-.21	-.14*

*All correlation coefficients are statistically significant, $p \geq .05$, except those designated with an *.

[a]Fleet mileage measures total daily mileage incurred by PRT vehicles. This and all subsequent definitions are drawn from the Weekly Conveyance Dependability Summary, West Virginia University, October 30, 1975.

[b]Actual operating hours measures the number of hours during which PRT service was provided.

[c]System availability is a dependability measurement. It is calculated in the following way: System availability = A = A' x F, where A' = Actual Operating Time ÷ Scheduled Operating Time, and F = Availability reduction factor due to fleet size. System availability measures PRT service actually provided in relation to planned service.

[d]Trip reliability is the probability that a rider will complete a trip without vehicle failure. It is calculated in the following way: trip reliability = number of completed vehicle trips ÷ number of attempted vehicle trips. From the rider's perspective, this measure represents vehicle reliability and perceived wait time while the system is operating.

[e]Vehicle availability is the mean number of vehicles available daily for passenger service. From the passenger's viewpoint, this reflects service characteristics such as wait time and in-vehicle crowding.

[f]Downtime frequency measures the total daily incidence of downtime episodes during system operation.

[g]Downtime duration measures the average length of delay experienced during a day.

Additionally, fleet mileage and actual operating hours had the strongest statistical relationship with ridership during both feeder services. Appendix C contains the intercorrelations between all system operating variables. The analyses suggest the following:

a. Increases in fleet mileage and actual operating hours, as proxies for system service and accessibility, are major encouragements to system use.

b. Conversely, the smaller and declining relationship between mean length of delay and ridership suggests ridership is least affected by length of a system delay.

c. The decreased relationship between system availability and ridership suggests that, with a competing bus service, riders were able to select an alternative mode.

d. The constancy of the relationship between trip reliability and ridership suggests that passengers quickly perceived system operating characteristics and adapted their travel patterns accordingly.*

3.2.3 Multiple Influence of System Operating Characteristics

It is useful to examine simultaneously the multiple impacts of these seven system operating characteristics on PRT ridership. The multiple impacts are measured during the operation of both types of PRT feeder service (see Table 3-2).

Fleet mileage alone accounts for the largest proportion of variation in PRT ridership, which is consistent with the results of the correlational analysis. However, the cumulative set of system operating characteristics varies by feeder service, despite the primacy of fleet mileage. Two points should be noted: during the spring semester under a competing bus feeder service, system operating characteristics accounted for more of the PRT ridership variance; additionally, the increments of variance in ridership accounted for by the second and subsequent system operating characteristics are quite small, which suggests that these measures

*A blinking light on the PRT station roofs indicated system breakdowns. Also, it has been mentioned that students occasionally called the PRT offices prior to traveling to inquire about PRT system functioning.

TABLE 3-2. THE INFLUENCE ON PRT RIDERSHIP OF PRT SYSTEM OPERATING CHARACTERISTICS

PRT SERVICE	SYSTEM OPERATING CHARACTERISTICS	PROPORTION OF VARIANCE IN RIDERSHIP EXPLAINED (R^2)[1]
PRT with Feeder Service (October - January)	Fleet Mileage	.83
	Fleet Milage and Actual Operating Hours	.85
	Fleet Mileage, Actual Operating hours, and System Availability	.86
PRT with Competing Bus Service (January - April)	Fleet Mileage	.87
	Fleet Mileage and Downtime Frequency	.89
	Fleet Mileage, Downtime Frequency, and Actual Operating Hours	.90
	Fleet Mileage, Downtime Frequency, Actual Operating Hours, and Trip Reliability	.91

[1]The stepwise multiple-regression procedure selected system operating characteristics sequentially in order of their contribution to the proportion of variance explained. Selection stops when subsequent system operating characteristics have statistically non-significant values, $p>.05$. Appendix C details the regression model used.

This chart shows that fleet mileage is the single most important explanatory characteristic of PRT ridership. The other characteristics in Chart 1 make slight though significant contributions to the explanation of PRT ridership.

are not independent. The following interpretations are offered:

a. Under modal choice conditions, ridership became more sensitive to system operating characteristics, as evidenced by the stronger statistical relationship between system operating characteristics and ridership.

b. The small increments of variance accounted for by the additional system operating characteristics suggest any one of these characteristics could be used as representative of the set of seven in relationship to ridership, without losing much statistical accuracy. It may be possible to estimate impact on ridership based on only one system operating characteristic.

3.3 SUMMARY

The influence of the PRT system operating characteristics on ridership is summarized as follows:

a. During academic year 1975-1976, the day-to-day variability in system operating characteristics and ridership diminished, although ridership continued to be responsive to system operating characteristics.

b. All seven system operating characteristics are related to ridership levels; fleet mileage has the strongest relationship with ridership.

4. CONCLUSIONS

The analysis describes PRT ridership volumes during initial passenger service and specifies the factors that influenced it. When PRT passenger service became available during the academic year 1975-1976, the system was still undergoing operational testing. This resulted in service interruptions and reduced hours of operation. In January 1976, when severe winter weather strongly impacted PRT system reliability and a three-week shutdown for a system retrofit became necessary, the University decided to operate the campus bus service on the same routes as in prior years, and in direct competition with the PRT system.

In order to recognize the significance of exogenous influences on PRT ridership, the conclusions focus on three topics: overall PRT ridership, the impact of system operations on PRT ridership and the impact of bus competition on PRT ridership.

4.1 OVERALL PRT RIDERSHIP

a. The PRT system was used for routine trips between the two campuses throughout the academic year.

b. When the PRT system was the only transit system between the two campuses and fully operational, it carried ridership comparable to the bus ridership in the pre-PRT study: 10,500 maximum PRT riders in fall of 1975 versus 10,252 average bus ridership in spring of 1975.*

c. Throughout the year, even with competitive bus service, the daily and weekly variations in PRT ridership corresponded significantly to changes in the campus activity levels.

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* Daily ridership volumes on the intercampus bus service which predated PRT service are reported by S.E.G. Elias et al., PRT Impact Study, Pre-PRT Phase, Volume I -- Travel Analysis. Morgantown, West Virginia University, March 1976. Final Report UMTA/MA-06-0026-76-11,1, pp. 52.

4.2 IMPACTS OF SYSTEM OPERATIONS ON RIDERSHIP

a. Variations in system operation influenced the availability and dependability of PRT service; however, when PRT operations became more regular towards the end of the 1975-1976 academic year, ridership stabilized correspondingly.

b. The seven system operating characteristics measured were highly interrelated and therefore appear to have relatively similar influences on ridership.*

c. Fleet mileage, or supply of service, had the strongest statistical relationship to ridership volumes, as one would expect in a demand-responsive system.

d. Ridership is least affected by average length of system downtime per day.

e. The constant relationship between trip reliability and ridership volume suggests passengers perceived system operating characteristics and adapted their travel patterns.

f. Ridership is more responsive to system operating characteristics when there is modal competition.

4.3 IMPACT OF COMPETING BUS SERVICE ON RIDERSHIP

a. When the PRT had operational difficulties during severe winter weather, bus service between the two WVU campuses was re-established. This service was in direct competition with the PRT system. This service was an exogenous event which allowed comparison of PRT ridership under captive and modal choice conditions.

b. The fall 1975 ridership volumes, with no modal alternative, represent PRT captive ridership. Maximum daily PRT ridership during this period was 10,588 for days when the PRT was fully operational. This ridership measures the basic levels of demand for intercampus travel.

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*The seven system operating characteristics are fleet mileage, actual operating hours, system availability, trip reliability, vehicle availability, downtime frequency, downtime duration. Definitions are presented in Table 3-1.

c. After January 28, 1976, the campus bus provided service between both campuses. At this time the rider could choose between bus or PRT service. PRT ridership averaged 3,100 per day during this period when the system was fully operational. This shows PRT service was chosen over bus service by many students.

d. PRT ridership during fall 1975 and through January 28, 1976 represents the base market for the PRT system. PRT ridership after January 28, 1976 may represent generated travel due to system features such as reduced waiting time, vehicle speed, comfort, and attractiveness compared with the bus alternative.

Operational testing of the PRT was completed and regular revenue service begun in August 1976. During the 1977 spring semester, the Post-PRT Phase of the Impact Evaluation is being conducted and ridership is being measured. Verification of the modal split and trip generation features of the PRT will be available from the results of the Post-PRT Phase of the Morgantown PRT Impact Evaluation.*

*The Post-PRT Phase of the Morgantown PRT Impact Evaluation is being carried out by contract with West Virginia University (DOT-TSC-1316).

APPENDIX A

PRT SYSTEM OPERATING CHARACTERISTICS AND RIDERSHIP

Figures A-1 through A-7 graphically present PRT system operating characteristics during academic year 1975-1976. This data includes weekends and vacations. Figures A-7 and A-8 show daily ridership during the academic year. Table A-1 describes 1975-1976 ridership. Table A-2 summarizes the descriptive statistics for the seven system operating characteristics. Table A-3 contains the source data on system operating characteristics and ridership reported for each day. Finally, Figures A-9 through A-11 describe PRT ridership by feeder service, by fare category, and by both feeder service and fare category.

TABLE A-1. SUMMARY OF 1975-1976 PRT RIDERSHIP

Daily PRT Ridership	1975-1976 Academic Year	October 23, 1975 to January 28, 1976 (Bus Feeder Service)	January 29, 1976 to April 28, 1976 (Competing Bus Service)
Mean	3,303	4,220	2,295
Maximum	10,588	10,588	5,867
Minimum	88	88	243
Mean Monday	3,911	4,883	2,615/962
Maximum Monday	8,622	8,522	3,693
Minimum Monday	627	627	984
Mean Tuesday	4,402	5,638	3,053
Maximum Tuesday	9,537	9,537	4,479
Minimum Tuesday	1,497	2,116	1,497
Mean Wednesday	4,338	5,582	2,982
Maximum Wednesday	10,588	10,588	4,212
Minimum Wednesday	637	637	1,376
Mean Thursday	4,591	5,934	3,248
Maximum Thursday	9,836	9,832	5,867
Minimum Thursday	2,078	2,346	2,078
Mean Friday	3,762	4,833	2,583
Maximum Friday	9,046	9,046	4,409
Minimum Friday	744	744	1,224
Mean Saturday	910	1,024	796
Maximum Saturday	2,414	2,414	1,061
Minimum Saturday	237	237	575
Mean Sunday	707	894	498
Maximum Sunday	2,041	2,041	759
Minimum Sunday	88	88	243
Mean Multiple Fare	3,083	3,981	2,095
Maximum Multiple Fare	10,344	10,344	5,652
Minimum Multiple Fare	49	49	144
Mean Single Fare	246	289	199
Maximum Single Fare	967	967	553
Minimum Single Fare	10	10	19

TABLE A-2. SUMMARY OF 1975-1976 PRT SYSTEM OPERATING CHARACTERISTICS

System Operating Characteristics	1975-1976 Academic Year	October 23, 1975 to January 28, 1976 (Bus Feeder Service)	January 29, 1976 to April 28, 1976 (Competing Bus Service)
System Availability			
Mean/S.D.	.80/.18	.74/.20	.88/.14
Maximum	1.00	1.00	1.00
Minimum	.06	.06	.29
Trip Reliability			
Mean/S.D.	.99/.01	.99/.01	.99/.01
Maximum	1.00	1.00	1.00
Minimum	.94	.94	.97
Vehicle Availability			
Mean/S.D.	16.4/4	16/4	17/4
Maximum	26.8	26.8	26.7
Minimum	5.5	6.2	5.7
Downtime Duration			
Mean/S.D.	.5/.5	.57/.5	.4/.55
Maximum	2.81	2.67	2.81
Minimum	0	0	0
Downtime Frequency			
Mean/S.D.	3.6/2.9	4.5/2.8	2.7/2.7
Maximum	13	13	13
Minimum	0	0	0
Actual Operating Hours			
Mean/S.D.	9.3/3.6	8.8/3.6	10/3.6
Maximum	22.4	14.4	22.4
Minimum	.5	.5	3.9
Fleet Mileage			
Mean/S.D.	1675/777	1582/765	1778/784
Maximum	3527	2962	3527
Minimum	65	121	65

TABLE A-3. SYSTEM OPERATING CHARACTERISTICS AND RIDERSHIP BY DAY

DATE	SYSTEM AVAILABILITY	TRIP RELIABILITY	VEHICLE AVAILABILITY	DOWNTIME DURATION	DOWNTIME FREQUENCY	ACTUAL OPERATING HOURS	FLEET MILEAGE	RIDERSHIP
10-23-75	.932	.981	20.7	.22	3	8.85	1,965	5,592
10-24	.791	.989	19.2	.37	5	7.63	1,745	6,180
10-25	.851	.987	21.9	.57	1	3.93	781	0
10-26	.815	.991	14.4	.15	5	4.73	885	1,918
10-27	.732	.981	17.6	1.06	3	9.82	2,244	7,564
10-28	.887	.994	22.0	1.47	1	11.53	2,550	7,123
10-29	.648	.984	18.2	1.51	3	8.47	1,659	5,462
10-30	.775	.976	16.1	.40	7	10.18	2,078	5,165
10-31	.838	.983	12.9	.17	6	11.98	2,017	6,212
11-1	.748	.980	14.4	.20	4	4.72	1,017	638
11-2	.597	.942	13.7	.34	5	3.78	558	1,512
11-3	.762	.993	11.4	.73	3	10.80	1,586	5,550
11-4	.738	.982	12.1	.69	4	10.23	1,430	3,797
11-5	.819	.995	12.0	.48	3	11.55	1,797	5,346
11-6	.834	.988	14.3	1.08	2	10.85	1,869	5,979
11-7	.951	.994	14.8	.21	3	12.37	2,264	6,089
11-8	.960	.981	16.9	.22	1	5.28	953	1,131
11-9	.909	.986	17.6	.50	1	5.00	892	2,041
11-10	.959	.997	14.1	.53	1	12.47	2,197	5,675
11-11	.906	.990	12.6	.61	2	11.78	1,752	5,894
11-12	.829	.976	12.1	.37	6	10.78	1,757	4,210
11-13	.841	.988	12.3	.21	4	12.15	1,935	4,995
11-14	.675	.992	8.3	.16	4	12.37	1,514	4,235
11-15	.705	.977	13.7	.80	2	3.90	914	1,607
11-16	.484	.994	9.5	.78	3	3.15	360	767
11-17	.933	.997	13.9	.00	0	13.00	2,082	5,188
11-18	.865	.989	14.2	.22	5	11.92	1,976	5,052
11-19	.844	.982	18.4	.38	5	11.10	2,204	5,092
11-20	.956	.998	14.6	.00	0	13.00	2,449	4,983
11-21	.858	.979	14.3	.50	3	11.50	2,171	4,328
11-22	1.000	1.000	17.2	.00	0	5.50	1,256	1,803
11-23	.500	1.000	15.6	.92	3	2.75	576	831
11-24	.837	.992	17.2	.94	2	11.12	2,043	5,777
11-25	.821	.991	17.6	.53	4	10.90	1,957	2,546
11-26	.843	.995	14.6	.28	5	11.58	994	637
11-27	DID NOT OPERATE - THANKSGIVING VACATION							
11-28	" " "			"		"		
11-29	" " "			"		"		
11-30	" " "			"		"		
12-1	.909	.992	16.9	.22	4	12.12	2,205	4,627
12-2	.863	.987	17.9	.59	4	11.45	2,282	4,467
12-3	.826	.991	18.8	.31	7	10.85	2,159	4,263

TABLE A-3. SYSTEM OPERATING CHARACTERISTICS AND RIDERSHIP BY DAY (CONTINUED)

DATE	SYSTEM AVAILABILITY	TRIP RELIABILITY	VEHICLE AVAILABILITY	DOWNTIME DURATION	DOWNTIME FREQUENCY	ACTUAL OPERATING HOURS	FLEET MILEAGE	RIDERSHIP
12-4-75	.962	.995	23.8	.24	2	12.52	2,569	4,725
12-5	.873	.985	25.2	.24	7	11.35	2,330	3,984
12-6	.700	.970	26.8	.57	5	6.65	1,527	2,414
12-7	.439	.991	19.6	1.03	3	2.42	437	536
12-8	.792	.980	17.1	.43	6	10.45	2,012	7,589
12-9	.860	.990	16.3	.22	7	11.47	2,575	8,925
12-10	.705	.980	14.6	.33	12	10.85	2,392	7,625
12-11	.943	.996	16.7	.22	2	12.57	2,165	9,836
12-12	.934	.997	19.0	.37	2	12.27	2,846	9,046
12-13	.923	.997	22.6	.21	2	5.08	1,064	1,109
12-14	.776	.986	20.4	.62	2	4.27	531	553
12-15	.714	.982	21.6	.37	10	9.32	2,120	2,683
12-16	.886	.989	25.5	.37	4	11.52	1,681	5,132
12-17	.853	.981	23.9	.21	9	11.10	1,683	3,075
12-18	.000	.000	0.0	13.00	1	0.0	0	0
12-19	.412	.993	9.3	6.42	4	6.58	1,002	744
12-20	.514	.948	11.4	2.62	3	2.88	508	328
12-21	.752	.983	12.1	.68	3	4.82	655	88
12-22	DID NOT OPERATE - WVU SEMESTER BREAK							
12-23	" " " " "							
12-24	" " "							
12-25	" " " " "							
12-26	" " " " "							
12-27	" " " " "							
12-28	" " " " "							
12-29	" " " " "							
12-30	" " " " "							
12-31	" " " " "							
1-1-76	" " " " "							
1-2	" " " " "							
1-3	" " " " "							
1-4	.000	-	-	5.50	1	0.00	0	0
1-5	.606	.981	8.5	0.24	9	10.87	1,143	1,016
1-6	.761	.978	13.0	0.30	7	10.90	1,453	2,166
1-7	.869	.994	12.8	0.34	2	12.33	1,962	6,118
1-8	.312	.962	14.5	0.96	9	4.38	853	2,346
1-9	.101	.987	6.2	2.67	4	2.32	527	997
1-10	.055	.957	6.2	2.49	2	0.53	121	239
1-11	.000	.000	0	5.50	1	0.00	0	0
1-12	.708	.971	12.6	0.26	11	10.17	1,744	6,160
1-13	.795	.979	14.2	0.35	6	10.88	2,045	8,473

TABLE A-3. SYSTEM OPERATING CHARACTERISTICS AND RIDERSHIP BY DAY (CONTINUED)

DATE	SYSTEM AVAILABILITY	TRIP RELIABILITY	VEHICLE AVAILABILITY	DOWNTIME DURATION	DOWNTIME FREQUENCY	ACTUAL OPERATING HOURS	FLEET MILEAGE	RIDERSHIP
1-14-76	.821	.981	15.0	0.24	9	11.72	2,497	9,646
1-15	.834	.982	16.0	0.23	8	11.17	2,439	9,458
1-16	.624	.975	18.9	0.80	6	8.18	1,852	6,171
1-17	.227	1.000	19.4	2.13	2	1.25	756	237
1-18	.533	.968	13.5	0.59	4	3.15	560	238
1-19	.499	.983	16.8	1.23	5	6.60	1,178	3,880
1-20	.831	.993	17.2	0.33	6	11.05	2,826	9,537
1-21	.952	.997	19.0	0.19	3	14.42	2,909	10,588
1-22	.484	.973	22.3	.66	10	6.38	1,492	6,262
1-23	.804	.987	14.8	.25	8	10.98	2,629	5,187
1-24	.661	.976	17.1	.93	2	3.63	763	737
1-25	.618	.983	17.2	.35	6	3.40	584	462
1-26	.877	.991	16.7	.43	3	12.70	1,874	8,622
1-27	.400	.984	18.2	1.55	5	5.25	1,349	5,032
1-28	.656	.974	15.2	.39	13	9.98	2,962	4,927
1-29	.883	.996	16.0	.29	4	11.83	3,358	5,867
1-30	.918	.990	17.9	.22	4	12.13	3,351	4,409
1-31	1.00	.997	17.9	0.0	0	5.50	992	624
2-1	1.00	1.000	17.9	0.0	0	5.50	959	565
2-2	.286	.971	6.8	.76	9	6.15	982	1,007
2-3	.950	.996	5.5	.25	1	14.25	3,527	4,479
2-4	.782	.995	16.0	.86	3	10.43	1,996	3,901
2-5	.529	.988	11.0	1.39	4	7.43	1,238	2,078
2-6	.823	.994	16.9	.98	2	11.03	2,583	2,208
2-7	1.0	.996	17.0	0.00	0	5.50	1,983	656
2-8	.724	.982	16.9	1.52	1	3.98	546	243
2-9	.741	.981	20.9	.30	11	9.72	2,046	3,695
2-10	.921	.992	25.9	.21	5	11.97	2,355	4,351
2-11	.892	.982	23.2	.17	9	12.48	2,250	4,212
2-12	.747	.978	18.4	.25	13	9.75	1,710	3,551
2-13	.534	.984	14.2	1.48	4	7.08	1,297	1,224
2-14	.809	.976	13.4	.17	3	5.0	749	749
2-15	.000	-	18.0	5.50	1	0	65	0
2-16	DID NOT OPERATE							
2-17	.817	.988	17.2	0.27	8	10.85	1,756	1,756
2-18	.351	.979	23.0	2.81	3	4.57	652	1,376
2-19	DID NOT OPERATE							
2-20	" " "							
2-21	" " "							
2-22	" " "							
2-23	" " "							
2-24	" " "							

TABLE A-3. SYSTEM OPERATING CHARACTERISTICS AND RIDERSHIP BY DAY (CONTINUED)

DATE	SYSTEM AVAILABILITY	TRIP RELIABILITY	VEHICLE AVAILABILITY	DOWNTIME DURATION	DOWNTIME FREQUENCY	ACTUAL OPERATING HOURS	FLEET MILEAGE	RIDERSHIP
2-25	DID NOT	OPERATE						
2-26	" "	"						
2-27	" "	"						
2-28	" "	"						
3-1	" "	"						
3-2	" "	"						
3-3	" "	"						
3-4	" "	"						
3-5	" "	"						
3-6	" "	"						
3-7	" "	"						
3-8	.829	.987	13.0	0.37	4	11.53	1,318	984
3-9	.773	.998	14.1	2.42	1	10.58	983	1,497
3-10	.848	.992	13.2	.23	4	12.10	1,340	2,270
3-11	.899	.987	17.4	.37	3	11.88	1,735	2,715
3-12	.818	.996	15.3	2.0	1	11.00	1,607	2,347
3-13	1.000	1.000	15.1	0.0	0	5.50	686	575
3-14	.979	.974	14.3	0.8	1	5.42	1,221	459
3-15	.754	.992	10.9	.37	4	11.53	1,873	2,969
3-16	.827	.991	11.0	.21	3	12.38	2,137	2,747
3-17	.874	.992	15.4	.37	3	11.88	3,014	2,200
3-18	.914	.998	13.3	.15	2	12.70	2,117	2,702
3-19	.862	.994	14.1	1.28	1	11.72	1,848	2,503
3-20	1.000	.994	15.5	0.00	0	5.50	996	1,061
3-21	1.000	.994	18.7	0.00	0	5.50	818	469
3-22	.936	.997	14.0	.11	2	12.78	2,711	3,131
3-23	.824	.995	11.4	.24	4	12.05	2,337	2,923
3-24	.935	.995	15.2	.43	1	12.57	2,495	3,130
3-25	.922	.991	18.3	.23	4	12.10	1,901	3,237
3-26	.8601	.992	12.3	6	6	11.97	2,165	2,991
3-27	.994	.998	14.0	0	0	5.50	1,079	777
3-28	.906	.997	14.5	1	1	5.05	855	759
3-29	.875	.996	13.6	3	3	11.98	2,468	3,050
3-30	.866	.994	13.1	2	2	12.35	2,775	3,522
3-31	.946	.997	14.7	1	1	12.95	2,359	2,980
4-1	.984	.998	17.0	0.0	0	13.00	2,452	2,997
4-2	.873	.991	16.3	0.43	3	11.70	2,168	2,196
4-3	.953	.996	19.7	0.37	1	5.13	1,071	802
4-4	1.000	1.000	18.0	0.00	0	5.50	863	719
4-5	.865	.988	16.5	.55	3	11.35	1,995	2,599
4-6	.789	.986	18.7	0.36	7	10.45	1,479	2,453

TABLE A-3. SYSTEM OPERATING CHARACTERISTICS AND RIDERSHIP BY DAY (CONCLUDED)

DATE	SYSTEM AVAILABILITY	TRIP RELIABILITY	VEHICLE AVAILABILITY	DOWNTIME DURATION	DOWNTIME FREQUENCY	ACTUAL OPERATING HOURS	FLEET MILEAGE	RIDERSHIP
4-7	.964	.992	21.1	0.45	1	12.55	2,749	2,968
4-8	.958	.993	22.0	.28	2	12.45	2,749	3,080
4-9	.894	.985	20.4	.34	4	11.63	2,656	2,699
4-10	.952	.998	21.0	.27	1	5.23	1,218	1,036
4-11	1.000	1.000	22.7	0.00	0	5.50	836	437
4-12	.955	.991	20.5	0.11	5	22.43	2,877	3,190
4-13	.969	.999	20.9	0.38	1	12.62	2,772	3,217
4-14	.940	.995	22.1	0.26	3	12.22	2,863	3,082
4-15	.955	.990	19.7	.15	4	12.42	1,913	3,069
4-16	.910	.993	15.7	.23	4	12.10	1,874	1,916
4-17	.909	.990	16.4	.50	1	5.00	964	815
4-18	.821	.969	21.0	.49	2	4.52	731	446
4-19	DID NOT OPERATE							
4-20	.886	.998	18.5	.46	3	11.63	1,994	3,521
4-21	.983	.999	17.5	.00	0	13.00	1,762	3,507
4-22	.950	.997	20.3	.22	3	12.35	1,643	3,191
4-23	1.000	.998	20.4	.00	0	13.00	1,990	3,338
4-24	1.000	1.000	22.3	.00	0	5.50	1,183	866
4-25	.709	.964	22.3	.80	2	3.90	478	390
4-26	.972	.993	21.1	.37	1	12.63	1,645	2,918
4-27	1.000	.995	22.9	.00	0	13.00	1,868	3,125
4-28	.987	.995	26.7	.17	1	12.83	2,195	3,177

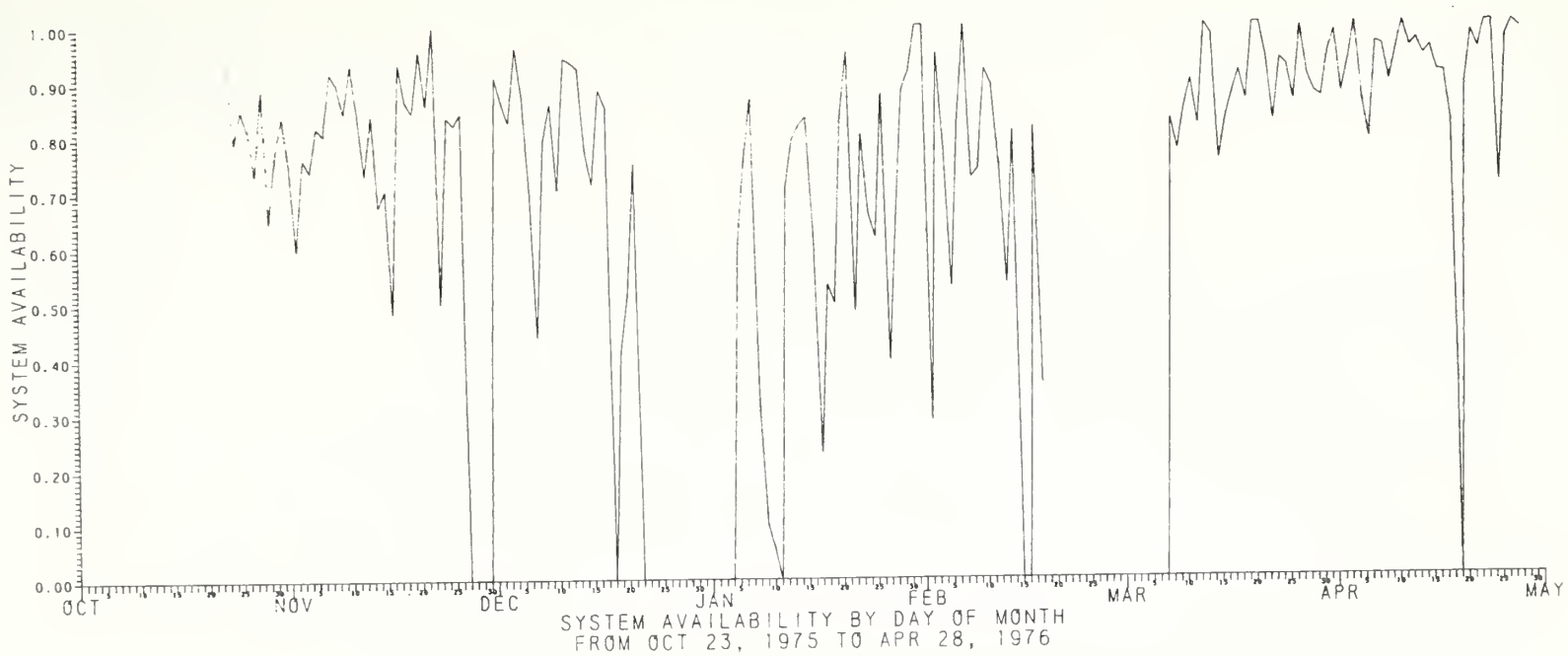


FIGURE A-1. SYSTEM AVAILABILITY, 1975-1976 ACADEMIC YEAR

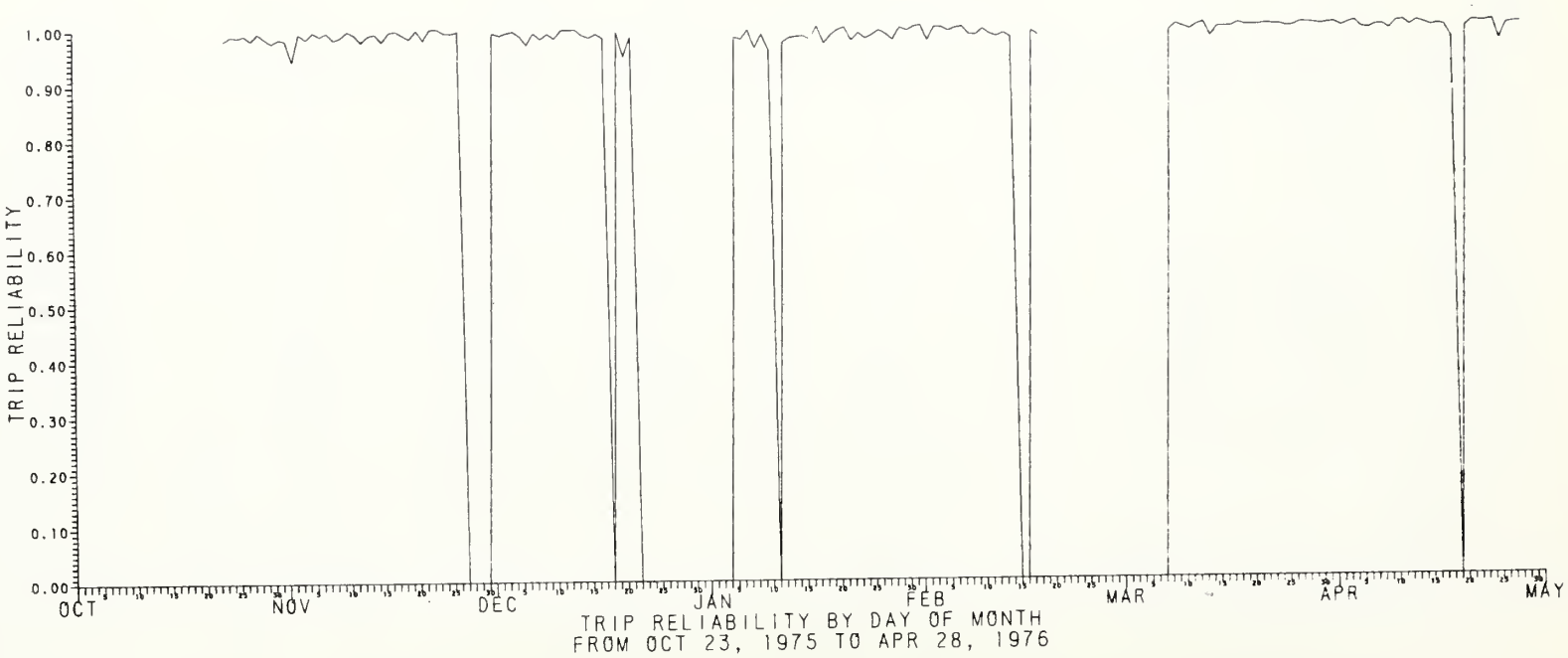


FIGURE A-2. TRIP RELIABILITY, 1975-1976 ACADEMIC YEAR

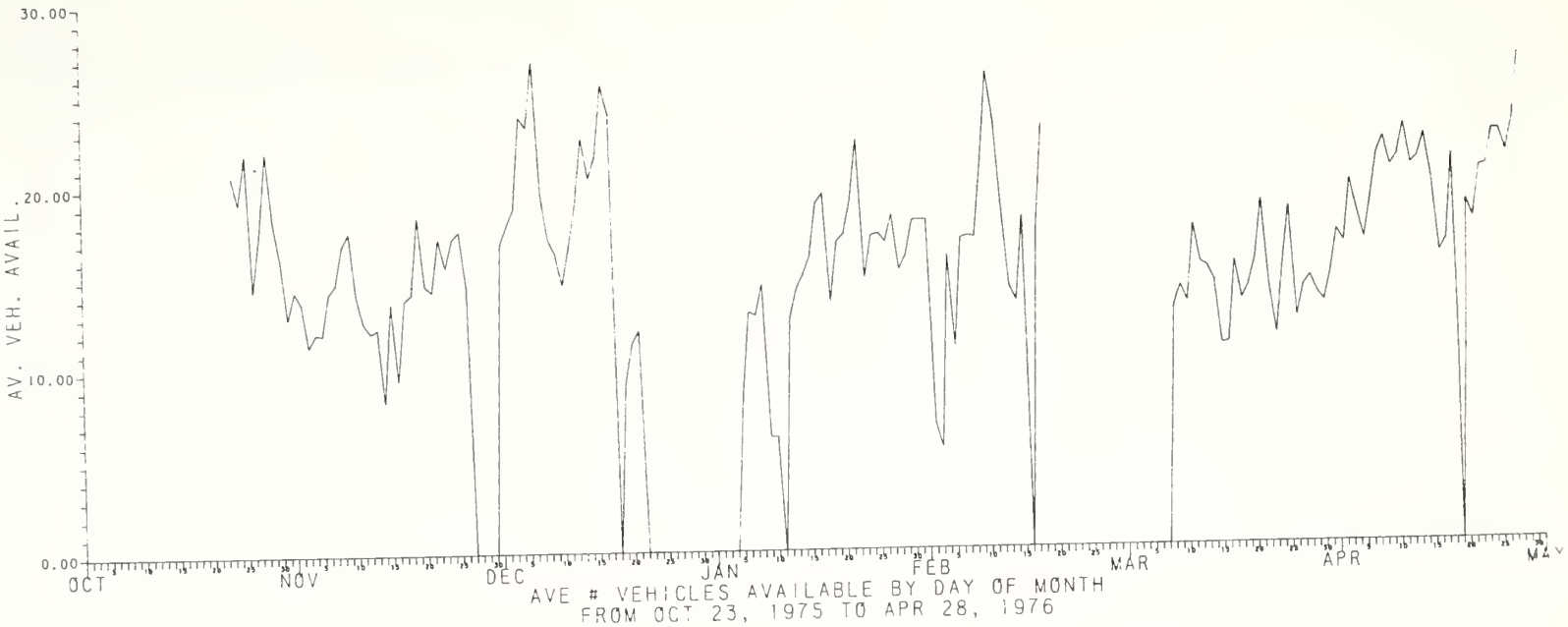


FIGURE A-3. VEHICLE AVAILABILITY, 1975-1976 ACADEMIC YEAR

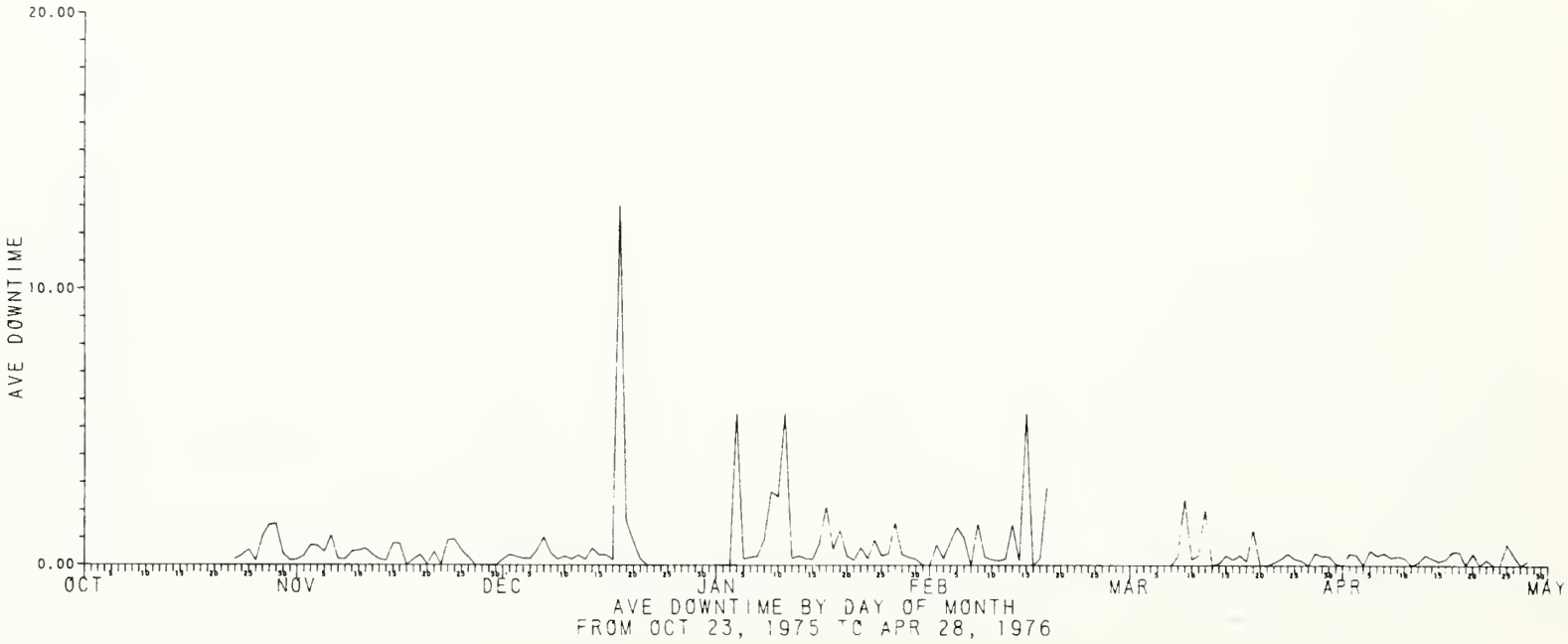


FIGURE A-4. DOWNTIME DURATION, 1975-1976 ACADEMIC YEAR

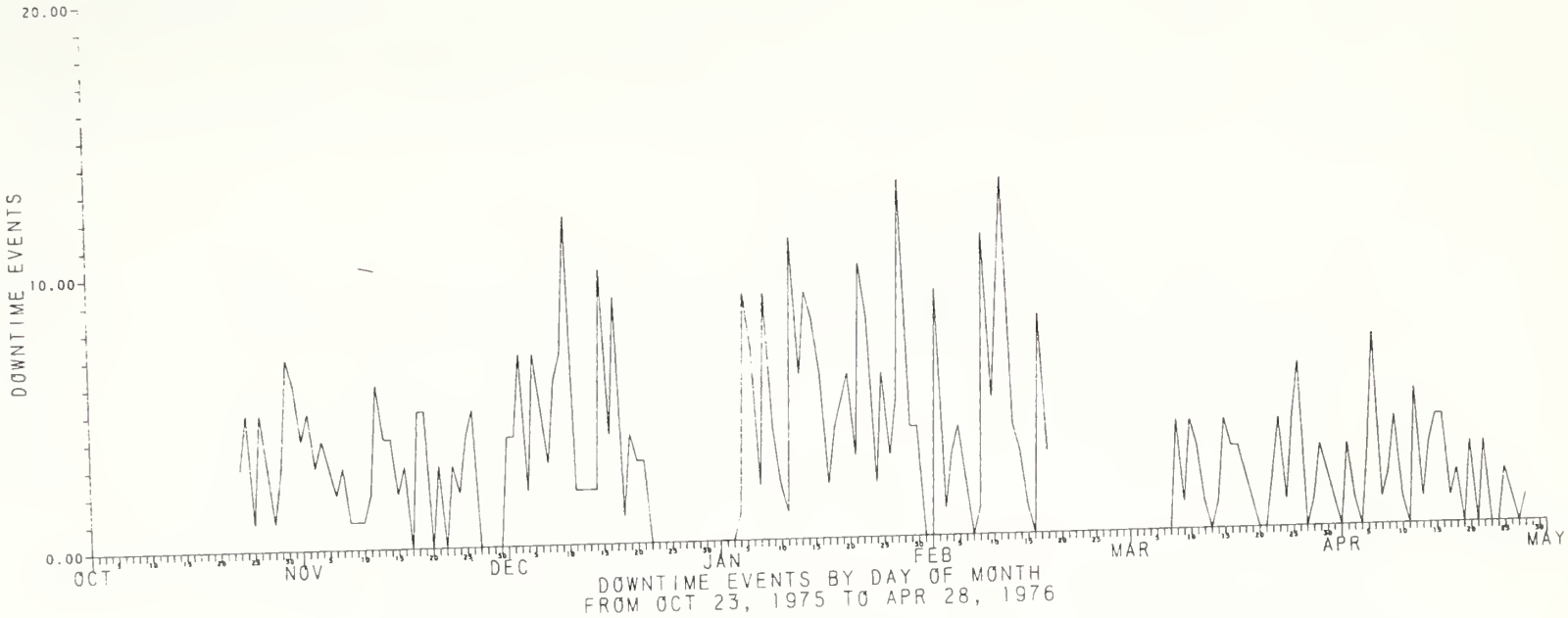
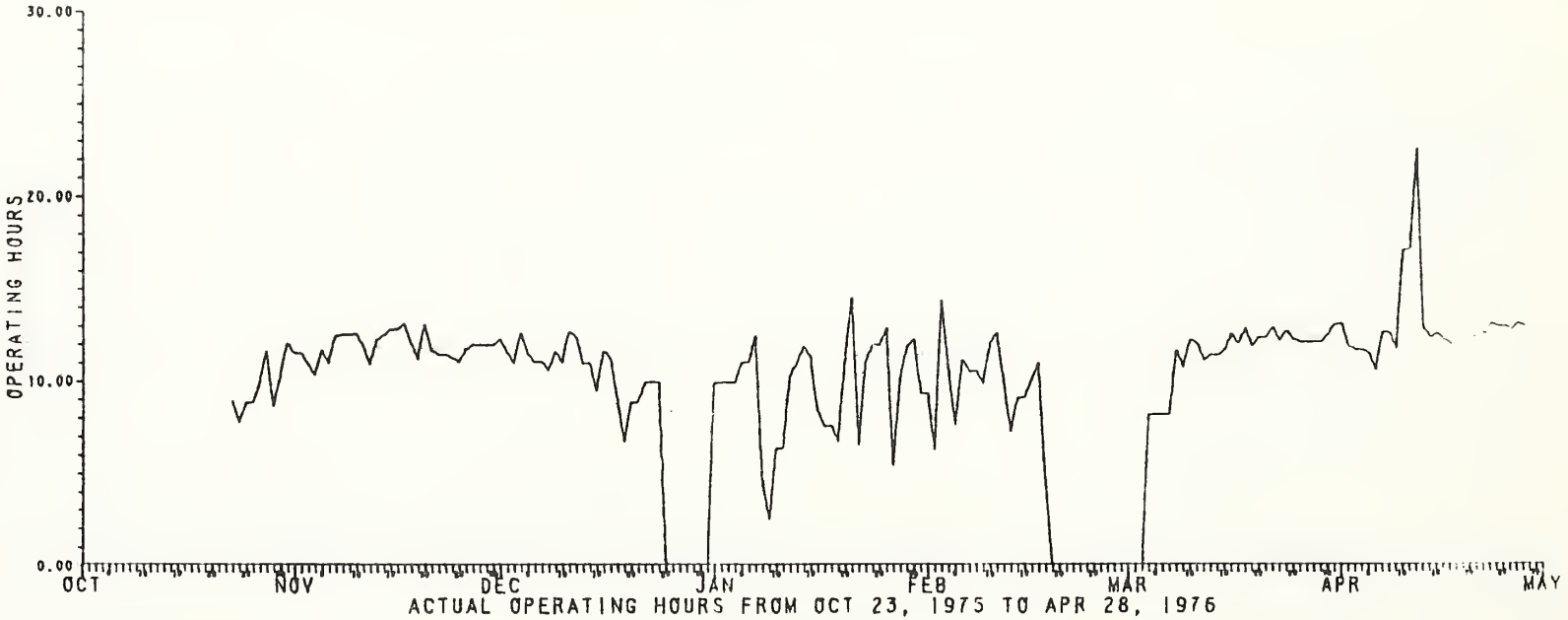
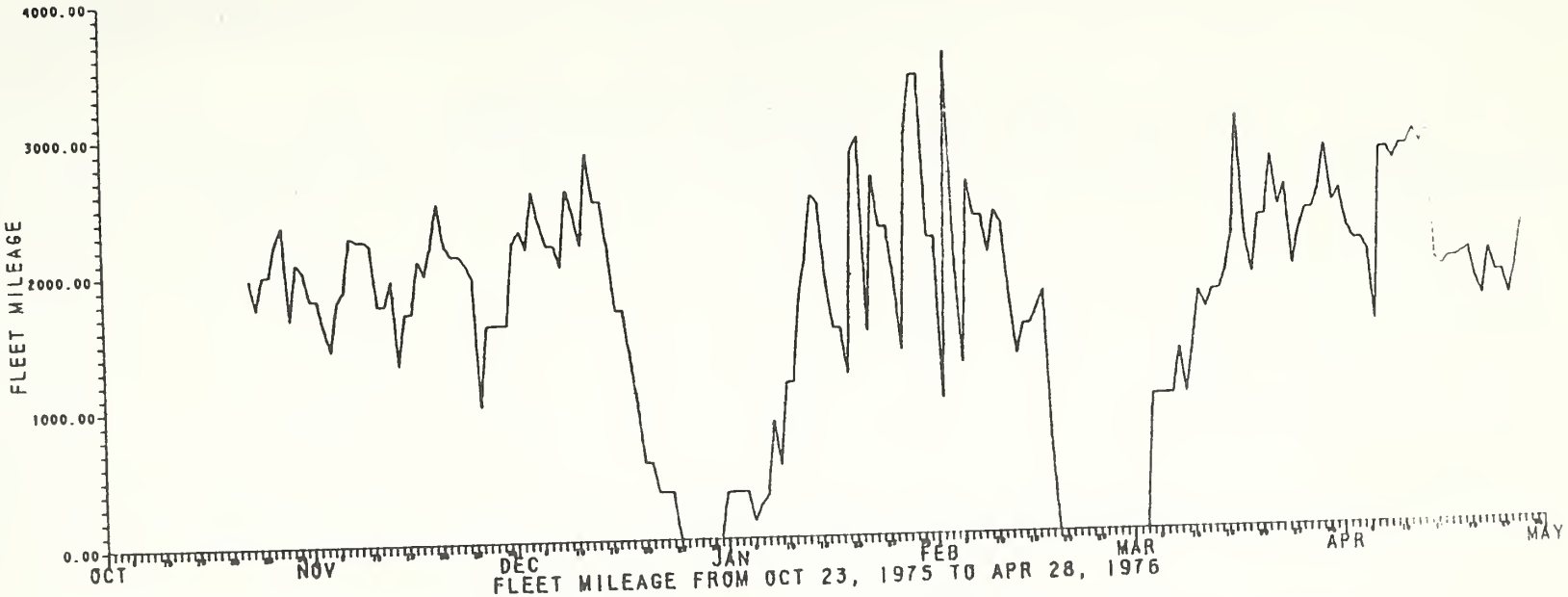


FIGURE A-5. DOWNTIME FREQUENCY, 1975-1976 ACADEMIC YEAR



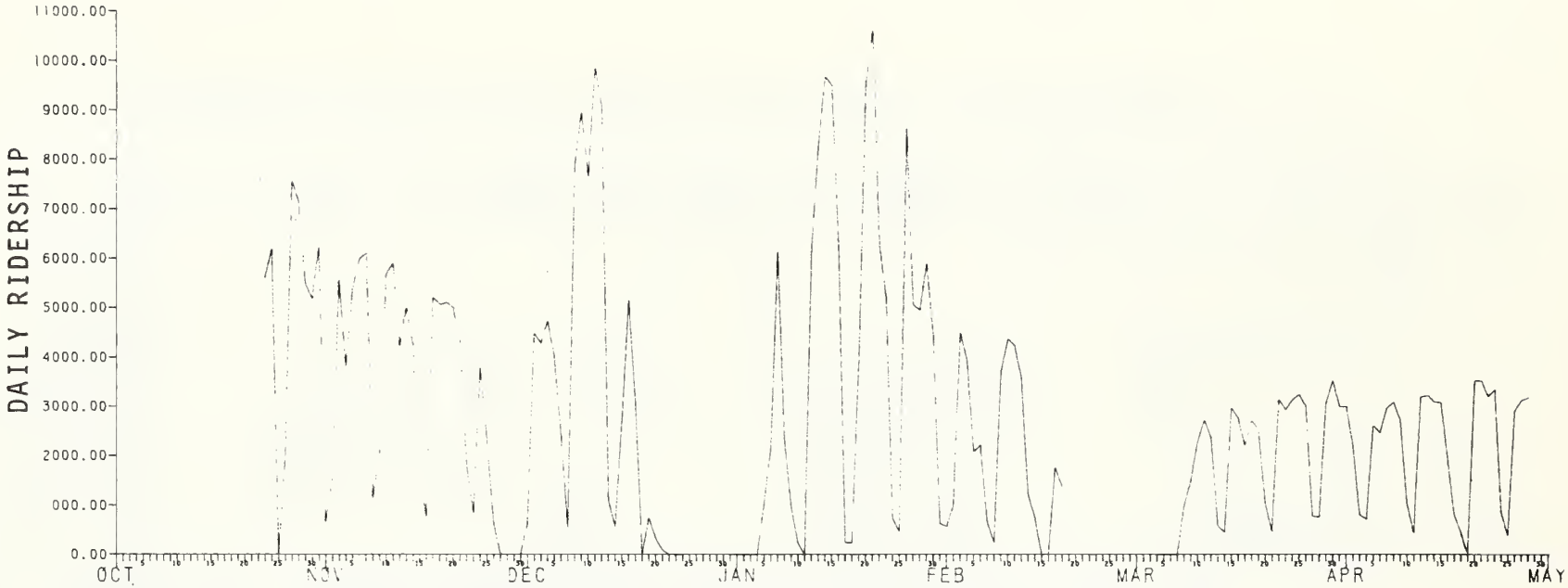
This figure contains actual operating hours only for weekdays; weekend levels are estimated as the mean daily level on the nearest Friday and Monday.

FIGURE A-6. ACTUAL OPERATING HOURS, 1975-1976 ACADEMIC YEAR



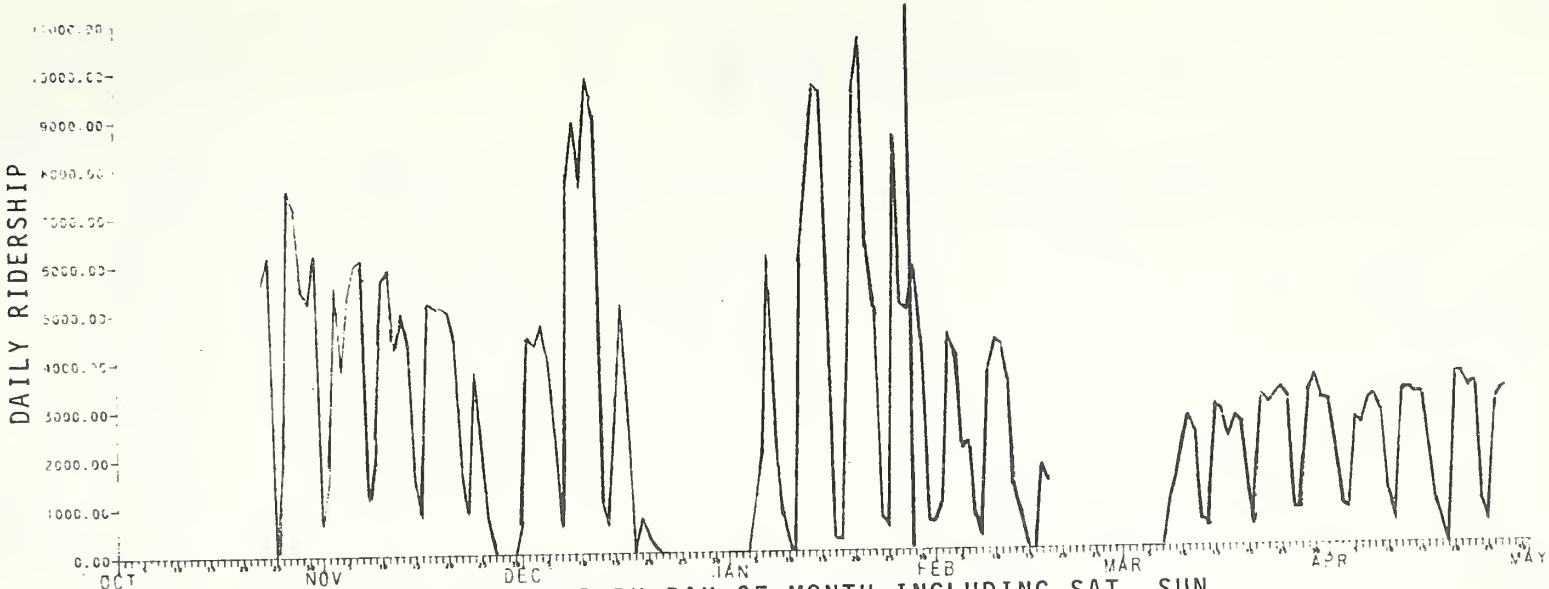
This figure contains fleet mileage only for weekdays; weekend fleet mileage is estimated as the mean daily level on the nearest Friday and Monday.

FIGURE A-7. FLEET MILEAGE, 1975-1976 ACADEMIC YEAR



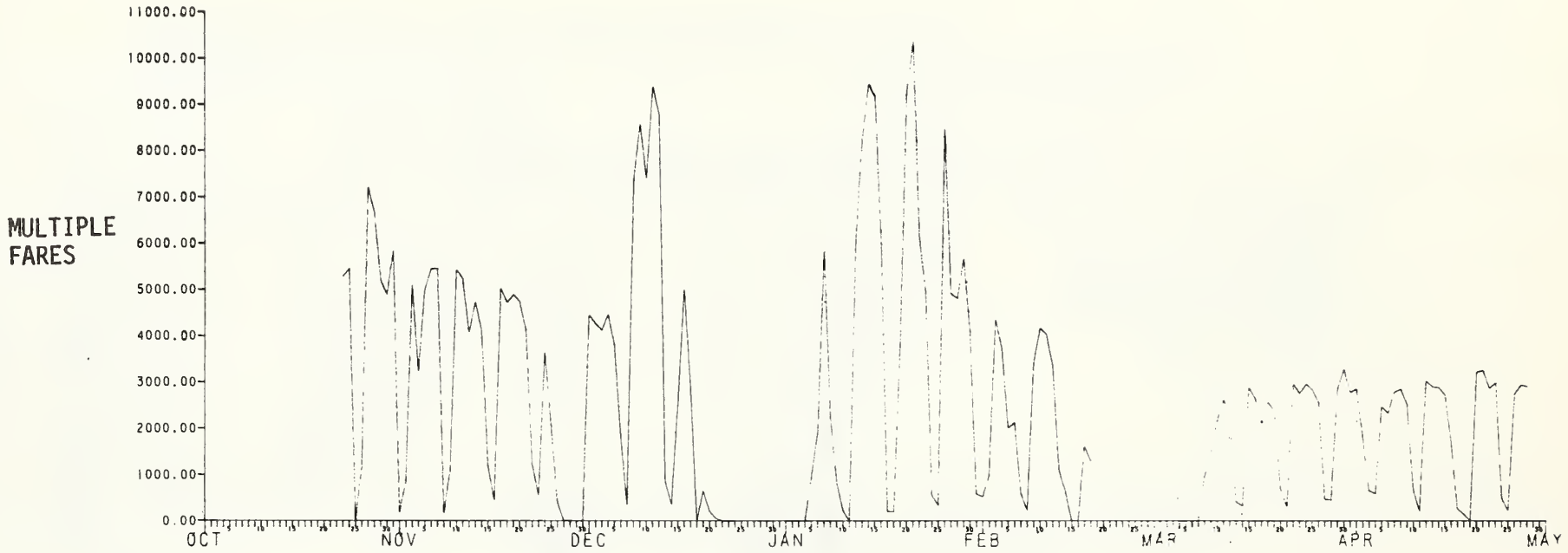
Blank spaces on horizontal axis indicate when PRT system did not operate.
Recurrent troughs on graph represent weekend ridership.

FIGURE A-8. 1975-1976 PRT DAILY RIDERSHIP



Blank spaces on horizontal axis indicate when PRT system did not operate.
Recurrent troughs on graph represent weekend ridership.

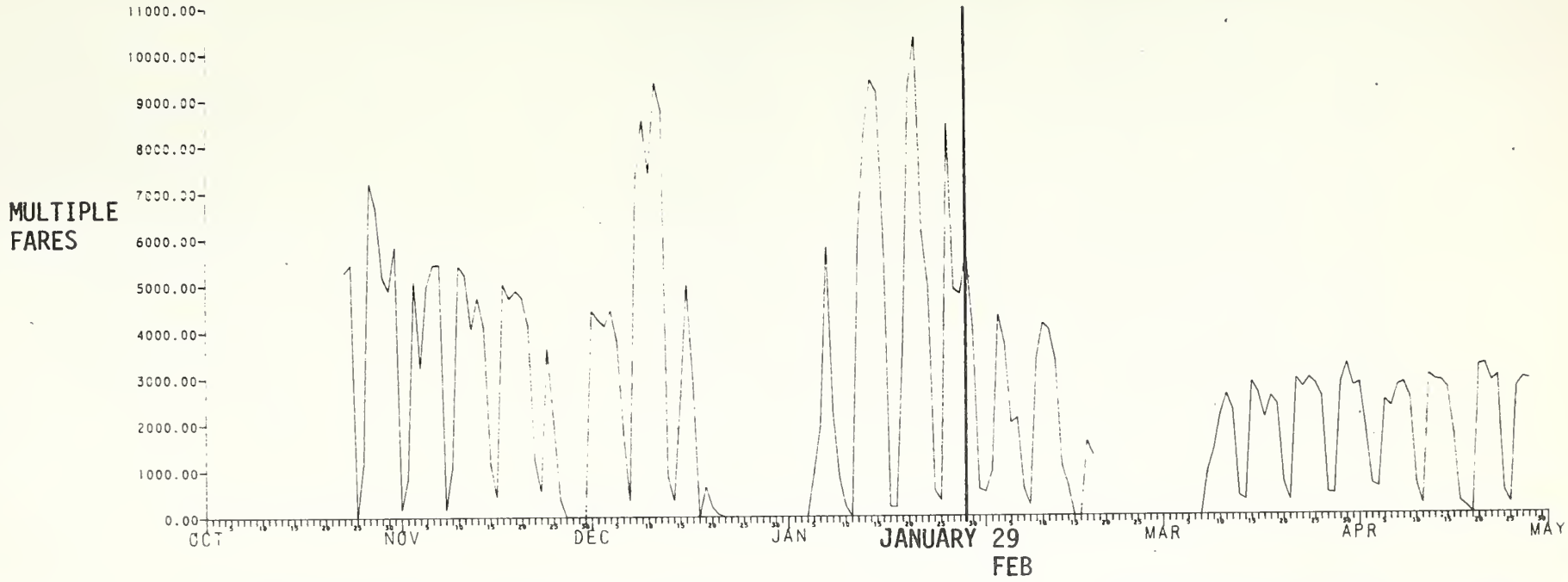
FIGURE A-9. 1975-1976 PRT RIDERSHIP BY FEEDER SERVICE



MULTIPLE FARES BY
DAY AND MONTH, OCTOBER 23, 1975
TO APRIL 28, 1976

Blank sections represent periods when PRT system did not operate. Recurrent troughs on graph represent weekend ridership.

FIGURE A-10. PRT RIDERSHIP BY FARE CATEGORY



Blank sections represent periods when PRT system did not operate. Recurrent troughs on graph represent weekend ridership.

FIGURE A-11. PRT RIDERSHIP BY FARE CATEGORY, BY FEEDER SERVICE

APPENDIX B

DATA

The data used for the Interim Analysis has been extracted from the Weekly Conveyance Dependability Summary. This is a management summary of the PRT system operating characteristics recorded by West Virginia University to monitor the operational testing status of the PRT system. TSC coded and statistically analyzed the ridership and system and service variables.

This study employs secondary analysis of this existing data source. It must be recognized that the data was originally collected for the purpose of operational monitoring by West Virginia University, not for ridership analysis. The original purpose of the data collection constrains this analysis by limiting the range of variables available.

This management system reporting format contained sufficient information on system availability and on total and student/non-student PRT ridership on a daily basis to allow data to be extracted. Table B-1 contains the code sheet used to extract variables.

TABLE B-1. CODE SHEET — INTERIM ANALYSIS

COLUMN	DESCRIPTION	CODING FORMAT	FIELD SIZE
1-3	Record ID	001	3
4-7	Date	1023	4
8	Day of week	1=Mon 2=Tue 3=Wed 4=Thur 5=Fri 6=Sat 7=Sun	1
9-13	Scheduled operating hours	09.50	5
14-18	Actual operating hours	08.85	5
19-23	Downtime	13.04	5
24-25	Downtime events	21	2
26-30	Average downtime	11.06	5
31-36	System availability	0.9815	6
37-42	Trip reliability	0.9947	6
43-48	Conveyance dependability	0.8436	6
49-50	Maximum no. of vehicles available	23	2
51-52	Minimum no. of vehicles available	14	2
53-56	Average no. of vehicles available	18.2	4
57-58	Number of vehicles operated	26	2
59-60	No. of vehicles removed due to failure	11	2
61-65	Fleet mileage	12583	5
66-69	Single fares	1292	6
70-74	Multiple fares	3151	5
75-79	Total no. of passengers		6

APPENDIX C

STATISTICAL ANALYSES

Appendix C contains details of the statistical analyses upon which this report is based. Following the report sequence, the statistical analyses are presented for Sections 2 and 3 separately.

In Section 2 analyses were conducted to determine whether the changes in mean daily ridership resulting from feeder service changes were statistically significant ($p \leq .05$). Determining statistical significance at $p \leq .05$ reveals whether the results obtained would be found less than 5 percent of the time by chance alone.

The Welch Test was applied to determine whether the difference between two time series was significant ($p \leq .05$), less than, or equal to what could be expected to occur less than or equal to 5 percent of the time. With the Welch Test there is no need to assume the two series are equal. The Welch Test has the following form:

$$t = \frac{\bar{x}_1 - \bar{x}_2 - \zeta}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

Where:

$\bar{x}_1, s_1^2$ and n are sample mean, sample variance and sample size of population 1 (one); x_2, s_2^2 and n_2 are sample mean, sample variance and sample size of population 2 (two); and ζ is a constant.

Significance testing was applied to the data in Figures 2-5 through 2-8. Following are the results:

a. Figures 2-5, 2-6: There is a significant decline in mean daily PRT ridership following conversion of feeder service to competing bus service, $t = 5.33$, $df = 145$, $p < .05$. There is a significant decline in mean weekday PRT ridership following conversion of feeder service to competing bus service, $t = 7.09$, $df = 106$, $p \leq .01$.

There is no significant difference between mean daily ridership levels on weekends (Saturday and Sunday) following conversion of feeder service to competing bus service. The results for Saturdays and Sundays, respectively, are $t=.95$, $df=18$ and $t-1.68$, $df=17$.

b. Figure 2-7: There is a significant decline in mean daily PRT ridership for each weekday following conversion of the feeder service into competing bus service. The results for the mean Monday ridership is $t=2.51$, $df=19$, $p<.05$; for mean Tuesday ridership, $t=3.61$, $df=21$, $p<2.01$; for the mean Wednesday ridership, $t=3.11$, $df=21$, $p<.01$; for the mean Thursday ridership, $t=3.4$, $df=18$, $p<.01$; and for the mean Friday ridership, $t=2.78$, $df=19$, $p<.01$.

c. Figure 2-8: There is a significant decline in mean daily student ("multiple fare") ridership following conversion of the feeder service to competing bus service, $t=5.29$, $df=145$, $p<.01$.

There is a significant decline in mean daily non-student ("single fare") ridership following conversion of the feeder service to competing bus service, $t=3.47$, $df=145$, $p<.01$.

In Section 3 the influence of system operating characteristics on PRT ridership is measured by calculating Pearson product moment correlation coefficients and a stepwise multiple regression.

Tables C-1 and C-2 present correlation matrices which contain correlations between all combinations of the seven system operating characteristics and ridership. The blank spaces in the matrices could contain mirror image values; these are omitted for clarity. Data used to construct the correlation matrices represent weekdays and weekends.

Table C-3 presents the details of the results of stepwise multiple linear regression analyses of the simultaneous influence on PRT ridership of PRT system operating characteristics. This table reveals only those system operating characteristics which have a statistically significant relationship ($p<.05$) with the criterion or dependent variable, ridership. Each of the system operating characteristics included in Table C-3 represents an

increment of variance explained in the dependent variable, ridership.

This analysis must be interpreted cumulatively and according to the sequence presented. It needs to be emphasized that those variables chosen by stepwise multiple linear regression are the best set of variables for the purpose of predicting total PRT system ridership. In no way does it imply that the variables not included are not essential or less useful than those favored by us. They may well be useful in evaluating PRT system performance in areas other than ridership.

TABLE C-1. CORRELATION MATRIX, SYSTEM OPERATING CHARACTERISTICS AND RIDERSHIP (BUS FEEDER SERVICE)*

	System Availability	Trip Reliability	Vehicle Availability	Downtime Duration	Downtime Frequency	Operating Hours	Fleet Mileage	Ridership
System Availability								
Trip Reliability	83							
Vehicle Availability	80	83						
Downtime Duration	-37	-29	-27					
Downtime Frequency	31	48	41	-15				
Operating Hours	85	68	59	-31	43			
Fleet Mileage	77	62	65	-26	45	86		
Ridership	62	49	46	-21	39	79	83	

* All correlation coefficients are statistically significant, $p \leq .05$ The values presented should be read with a decimal point in front of the number; values range between $\pm$ 1.00 for perfect correlation; with 0 representing no correlation.

TABLE C-2. CORRELATION MATRIX, SYSTEM OPERATING CHARACTERISTICS AND RIDERSHIP (COMPETING BUS SERVICE)[1]

	System Availability	Trip Reliability	Vehicle Availability	Downtime Duration	Downtime Frequency	Operating Hours	Fleet Mileage	Ridership
System Availability								
Trip Reliability	89							
Vehicle Availability	71	70						
Downtime Duration	-33	-14*	10*					
Downtime Frequency	02*	26	17*	02*				
Operating Hours	65	65	45	-17*	35			
Fleet Mileage	61	59	39	-20	30	87		
Ridership	46	48	37	-14*	43	84	87	

* All correlation coefficients are statistically significant, $p \leq .05$, except those designated with an *.

[1] See footnote on Table C-1.

TABLE C-5. STEPWISE LINEAR MULTIPLE REGRESSION, SYSTEM OPERATING CHARACTERISTICS AND RIDERSHIP

A. Bus Feeder Service (October 23, 1975 - January 28, 1976)

SYSTEM OPERATING CHARACTERISTICS	PROPORTION SUM OF SQUARES REDUCED	R^2	F	t	MODEL
FLEET MILEAGE	.69	.83	201.54	5.8	
ACTUAL OPERATING HOURS	.72	.85	110.13	3.7	
SYSTEM AVAILABILITY	.74	.86	80.60	2.6	RIDERSHIP = 2.14 (Fleet Mileage) + 322.6 (Actual Operating Hours - 2670.6 (System Availability) -58.94

B. Competing Bus Service (January 29 - April 28, 1976)

FLEET MILEAGE	.76	.87	235	5.7	
DOWNTIME FREQUENCY	.80	.89	140.09	3.2	
ACTUAL OPERATING HOURS	.81	.90	104.8	3.5	
TRIP RELIABILITY	.82	.91	84.2	2.2	RIDERSHIP = .9 (Fleet Mileage) + .87 (Downtime Frequency) + 118.2 (Actual Operating Hours) -709.3 (Trip Reliability) - 25.4

NOTE: Minus values in the regression model are statistical artifacts due to redundancy among the system operating characteristic measurements.

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